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FUTURE MEETINGS of the AMERICAN INSTITUTE of ELECTRICAL ENGINEERS

Place	Date	Nature	Manuscript Closing Date
New York, N. Y.	Jan. 23-27, 1933	Winter Convention	(Closed)
Schenectady, N. Y.	May 10-12, 1933	District Meeting	Feb. 10, 1933
Chicago, Ill.	June 26-30, 1933	Summer Convention	March 26, 1933
Salt Lake City, Utah	Aug.-Sept. 1933	Pacific Coast Convention	May-June 1933

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that such papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author important and helpful information explaining the Institute's rules relating to the preparation of manuscript and illustrations.

Future Meetings of Other Technical Organizations

Society and Nature of Meeting	Place	Date	Correspondent
American Assn. for the Advancement of Science, annual convention	Atlantic City, N. J.	Dec. 27–31	C. F. Roos, Permanent Secy., Smithsonian Inst., Washington, D. C.
American Institute of Mining Engineers, annual meeting	New York, N. Y.	Feb. 20–24, 1933	A. B. Parsons, Secy., 29 West 39th St., New York, N. Y.
American Physical Society	Chicago, Ill.	Nov. 25–26	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Physical Society	Pasadena, Calif.	Dec. 16–17	L. B. Loeb, Pacific Coast Secy., Univ. of California, Berkeley, Calif.
American Physical Society, annual meeting	Atlantic City, N. J	Dec. 28–30	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Society of Civil Engineers, annual meeting	New York, N. Y.	Jan. 18–21 1933	G. T. Seabury, Secy., 29 West 39th St., New York, N. Y.
American Society of Mech. Engrs., annual meeting	New York, N. Y.	Dec. 5–9	C. W. Rice, Secy., 29 W. 39th St., New York, N. Y.
American Society of Heating and Ventilating Engineers, annual meeting	Cincinnati, Ohio	Jan. 23–25 1933	A. V. Hutchinson, Secy., 51 Madison Ave., New York, N. Y.
American Society of Municipal Engineers, annual meeting	Detroit, Mich.	Jan. 16–20 1933	
National Assn. of Railroad and Utilities Commissioners, annual meeting	Hot Springs, Ark.	Nov. 15–18 1932	J. B. Walker, Secy., 270 Madison Ave., New York, N. Y.
Society of Naval Architects and Marine Engineers, 40th anniversary	New York, N. Y.	Nov 17–18 1932	H. G. Smith, Secy., 29 West 39th St., New York, N. Y.

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Officers and Committees (For complete listing see p. 678–81, September 1932 issue of ELECTRICAL ENGINEERING.)

MEMBERS of the Institute continue to make use of "Letters to the Editor" columns for the open-forum expression of their varied ideas on many subjects. *p. 813–15*

WHETHER OR NOT engineering progress benefits mankind depends upon how it is used, according to the fourteenth article in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" *p. 794–5*

IN THE FIRST 6 months of operation "not a single train delay has been caused by failure of the supervisory control equipment." Such is the report on the suburban electrification of an eastern railroad, all substations and switching stations of which are equipped with supervisory control. *p. 776–8*

BY DEPARTING from the conventional circular cross-section in cables used for transmitting electric power on overhead lines, the tendency of the cables to vibrate can be reduced; of several specimens tested, those having a triangular cross-section show least tendency to vibrate. *p. 795–8*

FROM an engineering study of the voltage and current wave forms of neon tubing commonly used for sign lighting, an explanation of its physical operation has been developed. *p. 772–5*

ENGINEERS have begun to plan for the relief of their unemployed during the coming winter. It is estimated that this year's needs will at least equal those of last year. *p. 809–13*

ALTHOUGH the thin oxid film with which aluminum protects itself from corrosion has been studied a great deal, only comparatively recently have thicker films produced "artificially" received much attention. These thicker films possess interesting properties and lend themselves to a variety of uses. *p. 778–80*

PEAKED voltage waves as narrow as 2 electrical degrees now can be obtained direct from a sinusoidal voltage source by the use of a specially designed transformer. *p. 802–4*

DEMAND for a simple and nondestructive method of testing finished welds has been met by an a-c bridge method with a visual balance indicator. Such a device is described in the A.I.E.E. 1931 national prize Branch paper. *p. 781–3*

PLANS for the A.I.E.E. 1933 winter convention already are assuming definite form. A general convention committee recently was appointed by President Charlesworth, and already has begun to arrange for the various events. *p. 807*

PREVIOUSLY published analyses of synchronous motor performance have been extended; from known formulas for the 3-phase short-circuit torque, expressions have been derived by which the torque from a single-phase short-circuit can be determined. *p. 799–801*

REGAINING stability in an electric power system is quite as important as maintaining it. To determine the proper operating procedure for quickly regaining synchronism once the system is out-of-step, an actual out-of-step condition on a large Pacific Coast system was exhaustively analyzed. *p. 769–72*

PROGRESS in insulation during the past year, both in theory and application, has been summarized in a report to the committee on electrical insulation of the National Research Council presented at the fifth annual meeting of the committee by its chairman, Dr. John B. Whitehead (F'12). *p. 765–8*

REGISTRATION at the recent A.I.E.E. district meeting at Baltimore totaled 240, attesting to the general interest value of the technical sessions as did the quality and quantity of discussions presented. Meetings of the Institute's board of directors, District 2 executive committee, and power generation committee, were held. *p. 805–8*

EVEN IN TIMES of low copper cost carrier communication has proved to be an economical means of conveying both telephonic and telegraphic information. A 10-channel 4-wire carrier telegraph system is capable of handling 3,360 words per min. *p. 784–9.* To lessen the labor involved in designing the shaping networks of this system, a direct method of solving coupled tuned circuits was developed. *p. 789–94*

Fig. 1. General view of Safe Harbor plant and dam

The Safe Harbor Hydroelectric Development

At Safe Harbor, Pa., has been built the third major hydroelectric plant on the lower reaches of the Susquehanna river. With an ultimate installed capacity of 510,000 hp in turbines, it is destined to become one of the largest hydroelectric developments in the United States. Turbines are of the propeller type with automatically adjustable blades; they are said to be the most powerful of this type ever built. Many interesting details of the development are revealed in this article.

By
N. B. HIGGINS
MEMBER A.I.E.E.

Safe Harbor Water Pwr. Corp., Baltimore, Md.

WHEN COMPLETED, the Safe Harbor plant will be one of the largest hydroelectric plants in the United States; initial development will include 6 generating units, which in an average year with full utilization will have an output of over 800,000,000 kwhr. The plant is situated along the Susquehanna river a few miles south of Columbia, Pa., and about 1,100 ft upstream from the mouth of Conestoga creek. The development ultimately will have an installed capacity of 510,000 hp in 12 Kaplan turbines, each of 42,500-hp capacity, operating at a speed of 109.1 rpm under a head of 55 ft. Ten of these turbines will drive 36,000-kva 60-cycle 3-phase, 80 to 100 per cent power factor, 13,800-volt generators; and 2 will drive 37,500-kva 25-cycle single-phase, 80 per cent power factor, 13,300-volt generators. Included also in the ultimate plan are 4 25/60-cycle frequency changers of the outdoor type, the generating ends of which will be rated at 31,250 kva, 80 per cent power factor, 300 rpm, 13,300 volts.

Initial development includes 5 60-cycle units, one 25-cycle unit, and one frequency changer; 4 60-cycle units are now in operation, and it is expected that another 60-cycle unit, one 25-cycle unit, and a frequency changer will be installed before the end of 1933.

A major problem in electrical design at Safe Harbor has been to produce a flexible layout, which will permit the installation as required of equipment for generating, transforming, and transmitting 60-cycle 3-phase, and 25-cycle single-phase energy. All generating equipment and the 60-cycle low-voltage bus are located in the power house; all 60-cycle transformers are of the outdoor type, and are located adjacent to the power house. A combined 69-kv and 230-kv 60-cycle substation ultimately will be built on the top of the hill, directly east of the power house. The frequency changers, 25-cycle low voltage bus, and 132-kv 25-cycle step-up substation will be located east of the power house.

One 230-kv circuit has been constructed between Safe Harbor and the Westport station of the Con-

Based upon "Safe Harbor Project" (No. 32-123) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 10-13, 1932.

solidated Gas Electric Light and Power Company in Baltimore, Md., and another will be constructed within the next few years, over a separate right-of-way entering the city from the east. A 69-kv double-circuit transmission line, about one mile in length, has been constructed to tie Safe Harbor into the existing 69-kv system of the Pennsylvania Water and Power Company.

The power house is in line with, and forms a continuation of the dam. The substructure is of reinforced concrete, and the superstructure of brick and tile. The total combined length of the concrete dam and power house is 5,000 ft, made up as follows: power house, 916 ft; bulkhead and abutments, 2,274 ft; spillway, 1,810 ft. The entire spillway is equipped with crest gates. General arrangement of structures is shown in Fig. 2.

In extent of drainage basin, and in total and average runoff, the Susquehanna river is the largest river flowing into the North Atlantic ocean, with the exception of the St. Lawrence. Its watershed includes 27,400 sq miles in the states of New York, Pennsylvania, and Maryland. Yet, in spite of this vast tributary area, the stream itself is of little use in commerce; there is practically no navigation above the tide-water limit, which extends only 5 or 6 miles upstream from the mouth of the river.

From Columbia to Tidewater, a distance of 39 miles, the river is walled in by steep bluffs or hills, and the main channel varies in width from a few hundred yards to almost 2 miles. Because of these conditions there has been no industrial development, other than transportation, in this reach of the river. These conditions of rapid descent, steep banks, and the absence of populous towns in a region close to large industrial centers, made this part of the river attractive from a power development standpoint.

Backwater from the dam extends 10 miles upstream forming a lake varying in width from 0.4 mile to almost 2 miles, covering an area of 10.5 sq miles. The water stored in the top foot of the pond is approximately 310 million cu ft; total useful storage is about 3 billion cu ft.

On the east side of the river, 8.5 miles of the Columbia & Port Deposit branch of the Pennsylvania Railroad had to be raised, and on the west side some highway relocation was required; otherwise, improvements effected within the reservoir limits were negligible.

Hydraulic Structures

It was desired to obtain full control of the forebay level for all possible river flows and to maintain constantly the maximum permissible forebay elevation, except when lowering would be desirable to make use of storage. This required a spillway that could be controlled with crest gates for its full length, and capable of discharging the greatest flood assumed possible at the given forebay elevation of 225 ft. Several comparative estimates were made to determine the most econonical combination of size and number of gates to produce these discharges. The final analysis resulted in selecting 32 gates for openings 35 ft high and 48 ft wide; tops of gates are 5 ft

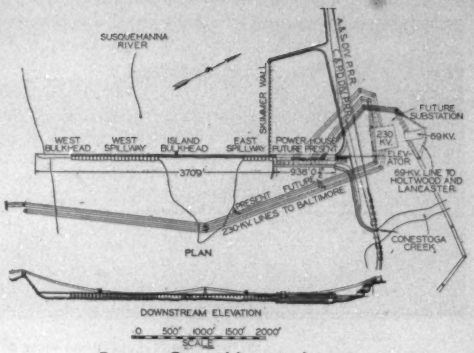

Fig. 2. General layout of structures

above initial normal pond level to prevent excessive loss of water from wind action.

At normal forebay level each flood gate will discharge about 30,000 cfs; the west spillway, where 24 of the 32 gates are situated, thus has a discharge capacity of 720,000 cfs, which is equal to the maximum flood of record.

Bulkhead sections are conventional gravity structures; they are designed for compression over the entire foundation joint for headwater at el 228, 10,000 lb per lineal foot of ice pressure at the same elevation, and uplift corresponding to full head at the heel decreasing to tailwater head at the toe following a gradient determined by the foundation drainage system. Design of the spillway is based upon the same assumptions, except that ice pressure there was reduced to 4,000 lb per lineal foot, acting on the gates and transmitted to piers. The lower assumption was considered justified because a compressed air bubbler system has been incorporated in the design to prevent ice pressure from acting on the gates.

The spillway has an overhung crest and a large bucket type of apron; otherwise, it is of the usual ogee cross-section. Shapes of the apron, spillway nappe, and pier noses, were determined by model tests in the Alden laboratory of the Worcester Polytechnic Institute. The dam stands on a sound rock foundation of quartz, mica schist, and phyllite. Because of the excellent quality of the foundation, the strike of the folds, and the dips of the stratum, no cutoff trench was required; natural conditions made it possible, in effect, to obtain cutoff trench advantages at little additional cost. Rock was removed by blasting operations, the average depth of excavation being 11 ft.

Crest gate equipment consists of 28 single-leaf Stoney flood gates, and 4 double-leaf regulating gates, the lower leaf of which is a Stoney gate and the upper leaf a fixed roller gate; there are also 2 emergency gates with fixed rollers. The upper leaves of the 4 regulating gates are operated normally by lowering them and discharging water over the top. By means of these gates, close regulation of pond level can be maintained, and floating debris and ice can be removed easily with a minimum waste of water.

Debris and ice usually will accumulate along the skimmer wall, for which reason the 4 regulating gates are located adjacent to the power house. Upper leaves of the regulating gates are operated by individual hoists located in a tunnel in the body of the dam directly under each gate. Hoist motors for the regulating gates have operating controls at the hoists and also in the power house switch room.

All crest gate equipment is handled by 2 gantry cranes of 150-ton capacity each. These cranes are served from a trolley bus on the operating bridge; in addition, one of the cranes is equipped also with a gasoline engine-generator set for emergency operation.

It is believed that every reasonable precaution has been taken to insure the safe operation of the crest gate equipment under the most unfavorable combination of circumstances. The following features are noted:

1. Large excess capacity of the gantry cranes.
2. One crane can handle gates with sufficient rapidity to meet any normal condition; 2 cranes are provided.
3. Different sources of power for the gantries.
4. Equipment to heat electrically the roller tracks and seal plates on the gate guides.
5. A compressed air bubbling system to prevent ice formation on the upstream side of the gates.

Flood gates are of the usual design of horizontal fabricated girders supporting a skin plate through vertical intermediate beams. The respective weights are 86 tons each for the flood gates (excluding roller trains), and 100 tons each (including fixed wheels) for the emergency gates.

Power House

Site selected for the power house is in the low-water channel of the river near the Lancaster county shore; minimum excavation for power house and tailrace was an important consideration in the selection of this site. The ultimate length of the power house will be 916 ft; the initial section is 642 ft long, with space for 7 main generating units. A railroad connection extends directly into the generator room assembly bay.

Physical dimensions of the Safe Harbor turbines are the largest for this type of unit so far installed in this country. The maximum scroll case and draft tube width is 55 ft; thickness of piers between units is 7 ft, making the unit spacing 62 ft. Below the water line all contraction joints are sealed with crimped sealing strips made of 24-oz copper, while construction joints between lifts of concrete are sealed with flat copper strips.

Offsetting by 2.5 ft the transverse center line of units with the transverse center line of the intakes presented some difficulty in lining up the piers between waterways; this was overcome by slightly tilting the upper part of the draft tube. Characteristics of the turbines selected required a deep draft tube, but the influence of this on volume of tailrace excavation was reduced by sloping the bottom of the outflow end of the tube upward at the steepest permissible angle without affecting the draft tube efficiency. From low point to exit the draft tube is divided into two equal outlets by a 5-ft pier. For unwatering, the tube can be sealed by a set of sliding gates which are handled by a 25-ton gantry crane from a bridge over the tubes.

From the draft tube outlets the tailrace floor slopes upward to intersect the natural river bed at an angle of 6°. The maximum depth of rock excavation was about 40 ft, 180,000 cu yd of solid rock being excavated to form the tailrace channel. This excavation is the total for the ultimate plant; likewise, the substructure was excavated for all future units.

Intake portion of the power house substructure for the 5 future units was completed, excepting that no intake gate hoists or screens were installed. Intake gates for future units were an important part of the scheme for the control and discharge of the river flow during closure of the last cofferdam.

Floors of the intakes are level at approximately the same elevation as the floor of the forebay; each in-

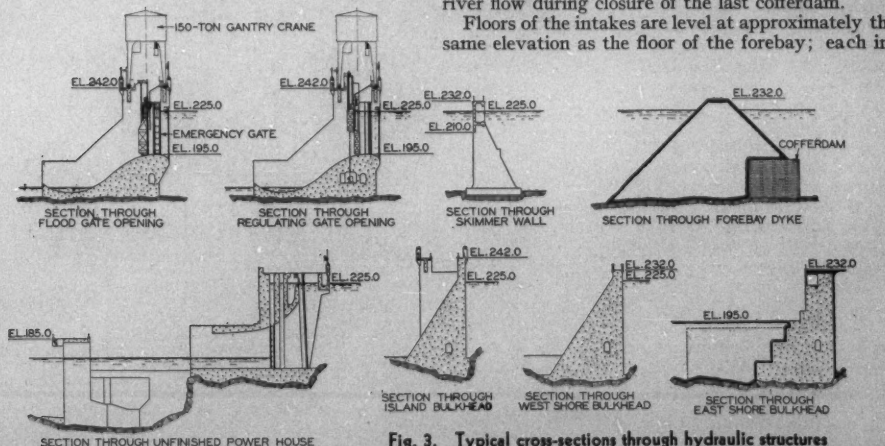

Fig. 3. Typical cross-sections through hydraulic structures

take consists of 3 water passages, with smooth sloping bell mouths. The cross-section of the water passages at the head-gates measures 15 ft 8 in. wide by 29 ft 4½ in. high. Each water passage is controlled by one intake gate; slots are provided in the head works in front of head-gates for the placing of emergency gates when head-gates are taken out of service. Velocities through the gross area of the intake cross-sections vary from 3.32 ft per sec at entry to 7.25 ft per sec at the scroll case intake.

The center gate of each intake travels on fixed rollers, and is operated by a motor-driven screw hoist; the 2 outside gates are sliding gates, and are handled by a 50-ton intake gantry crane, of which 2 are provided. The screw-hoist-operated gate can be raised or lowered under full unbalanced water pressure. The sliding gates are designed to be handled under balanced water pressure only. Emergency valves are provided in the sliding gates for filling the intakes in the event of screw hoist motor failure. The omission of hoisting mechanism on ⅔ of all head-gates resulted in a substantial saving in cost, and does not slow up the starting operation appreciably as a unit can be started with the center gate alone open. Emergency gates are similar to the sliding head-gates and are handled in the same manner.

Intake screens are of welded construction throughout. A single intake screen is made up of 5 vertical sections 12 ft high by 18 ft wide, and slides in slots similar to the gate slots. The face of the screen has a batter of 1 in 24. Individual screen bars and their supporting frame are designed for an unbalanced head of 15 ft of water. Screen bars and supports of streamline shapes were designed to offer a minimum resistance in the water passages. In addition to reducing the loss of head, a flow free of eddies will decrease the tendency for frazil ice to adhere to the screens.

There is provision for a mechanical trash rake, but the rake will be installed only if found necessary. Surface trash and ice that may collect at the turbine intakes can be discharged directly over the screens into the trash sluice built into the substructure. The crest elevation of the sluice is one foot below normal forebay level, and is closed off from the forebay by gates; these gates when raised permit the discharge of all floating debris into the sluice, from where it is carried directly to the tailrace. Compressed air can be discharged at points on the periphery of the intakes to dislodge and float waterlogged debris.

In addition to providing for heating the screens electrically, should this prove necessary, another means to reduce or eliminate ice troubles in the intakes is a provision to discharge the air from the exhaust duct tunnel of the power house ventilating systems, into the space over the screens and below the intake deck.

Arrangement of Electrical Structures

The electrical bay of the power house, as may be seen from Fig. 4, is between the generator room and the intake structures. It consists of 3 floors housing switching equipment. The lowest floor is occupied by the 2 buses and their taps; the second floor houses oil circuit breakers and disconnecting switches; the third contains potential transformers and reactors. A vertical reinforced concrete fire wall separates the 2 buses and their associated switching equipment. Crosses are made only at those points where taps are taken off to machines, and special attention has been paid to making these vapor-tight.

Above the electrical bay are the transformer pockets, each approximately 40 x 30 ft in size and separated by vertical fire walls one foot thick. Below each transformer is a basin, drained to the tailrace and of sufficient size to accommodate all of the oil in the transformer tank.

The takeoff structure supporting the isolating transformer disconnectors, the lightning arrester disconnectors, and outgoing lines across the forebay are directly above the transformers. Safe and quick maintenance on all switching equipment on this structure is made possible by a complete system of access ladders and working platforms.

In the center of the station a space 165 ft long above the electrical bay is devoted to the control and terminal rooms, batteries, station service transformers, and station service switchboards.

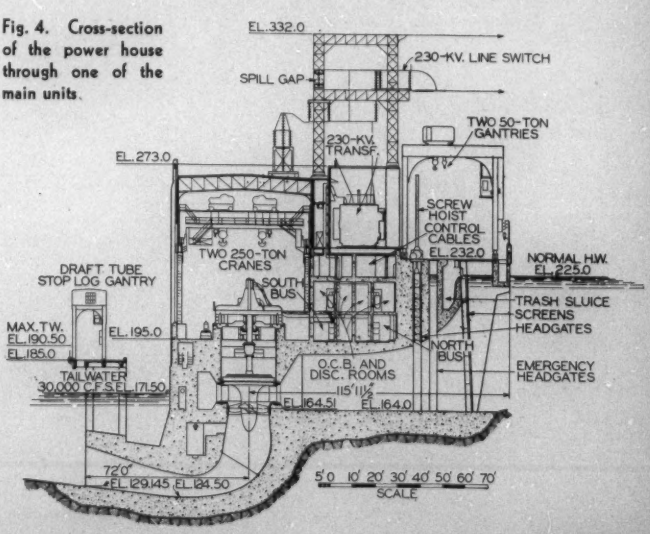

Fig. 4. Cross-section of the power house through one of the main units.

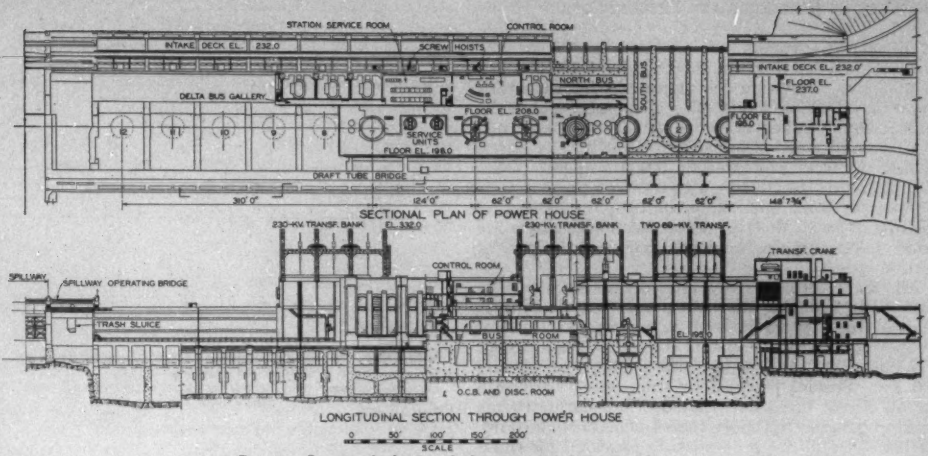

Fig. 5. Sectional plans and elevations of the power house

60-Cycle Generating System

The 60-cycle generators, of which 4 now are installed, are 3-phase machines, each rated at 36,000 kva, 80 to 100 per cent power factor, 13,800 volts, at 80 deg C temperature rise in both armature and field. As may be seen from Fig. 6, these generators feed into a double bus system which ultimately will consist of 8 sections with 4 sections per bus. The bus and its connected equipment are designed to operate ungrounded; therefore the generator neutrals have been grounded only through potential transformers to which ground indicators are connected. From this bus power is supplied to the 230-kv and 69-kv step-up transformer banks of which ultimately 3 each will be installed. Equipment is connected to the bus by selector oil circuit breakers. Reactors will be installed as needed to hold the short circuit values below 1,500,000 kva.

Only the simplest high voltage switching is provided at the power house. This consists of a motor-driven isolating disconnect with ground switches for each transformer. Lightning arresters, spill gaps, and the lightning arrester disconnecting switches for protecting the transformers also are located at the power house, one set being connected to the outgoing leads of each transformer. At the present time there is no high-tension bus, each transformer bank being connected directly to a transmission line. Either or both of the 2 230-kv transformer banks can be tied to the single 230-kv Baltimore circuit.

The generators are of the overhung rotor type (see Fig. 7) with water-cooled guide and thrust bearings combined in a single housing below the rotor. Guide and the thrust bearings are of the adjustable segmental shoe type; the thrust bearing is designed to carry a total weight of 1,500,000 lb, including a water thrust of 1,100,000 lb. These machines are designed to withstand overspeed to 231 per cent of normal, which value, like that of the water thrust, is somewhat greater than usual on account of the characteristics of the Kaplan turbines.

Diameter of the generators is 29 ft 2 in. and the height 29 ft measured from the lower face of the coupling to the top of the Kaplan head. The weight of a complete machine is approximately 400 tons.

Manufacturers of the generators cooperated in the design of the machines in order to make parts interchangeable as far as possible; those parts exposed in the generator room are identical in appearance.

Class B material is used throughout for insulating the generators. While it is not believed that machines of this size and importance should be operated continuously at the 80 deg C temperature rise, it was decided that excitation should be provided to permit development of the rating corresponding to this rise for use during peaks or emergencies. Normal operation at approximately 28,000 kw, 90 per cent power factor falls within the 60 deg C temperature rise in both armature and field, a rise generally accepted as conservative design practise for this class of insulating material.

A closed system of recirculating air is employed for cooling the generators. Air is introduced below the rotor and is forced by fans attached to the rotor through the windings into an eccentric frame, which serves as a duct to collect and conduct the hot air to the surface air coolers located on diametrically opposite sides of the machines (see Fig. 7). A gravity system of water supplied from the forebay serves the coolers. The air path is totally enclosed throughout; the ducts are equipped with louvres which may be opened as required to bleed air for heating the generator room. The closed system of ventilation was selected rather than open ventilation for the following reasons: reduction in space; better control of generator temperatures; better fire fighting possibilities, and the exclusion of foreign material (particularly construction dirt).

Oil Circuit Breakers and Disconnects

Oil circuit breakers are insulated for 25 kv and are designed to interrupt successfully 1,500,000 kva at 13.8 kv. They are cell mounted with each tank in an individual concrete cell. Generator and 69-kv transformer breakers are rated at 2,000 amperes, and have normal speed of operation. The 230-kv transformer breakers are rated at 3,000 amperes (2 are used in parallel) and have a guaranteed opening time of 8 cycles from application of tripping current to clearing of arc. Bus tie and bus section breakers are rated 4,000 amperes, and are designed to open at normal speed.

All circuit breakers are interlocked mechanically with their isolating disconnectors. Interlocking is effected further throughout high voltage electrical areas, where the Cory system is used to lock switches and bus doors on 13.8 kv, and switches on 69 and 230 kv. Special precautions were taken to isolate the oil circuit breakers; they are in separate rooms with, in general, not more than 4 breakers in a room. Carbon dioxide fire protection is provided for these rooms, and oil sumps below each breaker tank are drained to the tailrace.

Disconnecting switches isolating the oil circuit breakers are designed so that the 6 poles are operated by one mechanism. When in the open position they are swung into ground clamps, thus isolating and grounding the breaker. All disconnecting switches are mounted on insulators interchangeable with those supporting the bus runs and taps.

230-Kv Transformers

The 230-kv transformers are of the combined gas filled-conservator type in which a 16-in. nitrogen filled space, directly below the cover, is kept under positive pressure by the head of oil in a standard conservator. Expansion and contraction is taken care of by variation of the conservator oil level. They may be operated as standard conservator transformers, if desired.

At present 2 230-kv transformer banks have been installed. Each bank has a normal capacity of 84,000 kva when operating self-cooled, and 126,000 kva with blowers in operation. One bank only is now complete with blowers; blowers are omitted on the second bank because at present it is used only as an emergency spare bank.

The 3 single-phase units comprising each bank are in individual cells; they are Y-connected on the 230-kv side and Δ-connected on the 13.8-kv side. The high voltage neutral is solidly grounded, but the installation is such that the banks may be grounded later through an impedor of such size as will hold the transformer neutral voltage below 76 kv. Four $2^1/_2$-per cent taps are provided in the high tension winding, 2 above, and 2 below 230 kv. The transformers are insulated to withstand an induced test of 461 kv. Their windings and bushings are designed to be coordinated with each other and with a 46-in. protective gap on the high-tension structure adjacent to the transformers. Each transformer is protected by a thyrite lightning arrester mounted on the power house roof adjacent to the transformers.

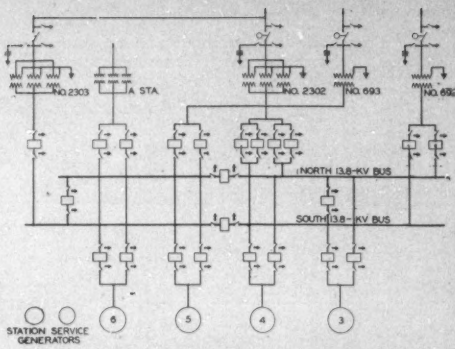

Fig. 6. Single-line diagram of the 60-cycle system

Note that each main transformer is connected directly to a transmission line

In addition to the 230-kv transformers, 2 69-kv transformer banks have been installed; these are 3-phase 30,000-kva self-cooled banks of the inertaire type, equipped with blowers to increase this rating to 45,000 kva. They are equipped for tap changing under load over a range of 10 per cent above and below 66 kv. Each transformer is protected by an autovalve lightning arrester mounted on the roof close to the transformer leads; protective gaps are not used at this voltage.

Auxiliary Power Supply

Major auxiliaries at Safe Harbor are supplied at 460 volts from 2 2,500-kva, 70 per cent power factor, house generators, and a single-phase transformer bank of 2,500 kva capacity connected to the main 13.8-kv bus. The house generators are of the umbrella type, and are driven at 180 rpm by 3,100-hp Francis turbines.

There are 2 station buses, each of 2 sections, complete with section switches and one bus tie switch. Positions are available for connecting each of the house generators and the transformer banks to either bus; normally one house unit is connected to each bus. These buses are isolated from each other, each being contained in a steel structure and the 2 separated by a 7-ft aisle. Generators, transformer, and tie and section circuit breakers are of 4,000-amp capacity. All feeder breakers are of the truck type.

Excitation System

The unit system of excitation has been adopted, supplemented by a motor-driven spare exciter supplied from the station auxiliary system. Each of the main generators receives excitation from a 185-kw 250-volt main exciter and pilot exciter, both mounted above and direct-connected to its generator.

Provision is made for the future addition of a second spare exciter, if found necessary.

Generator main field rheostats are not required, as the generator voltage is controlled by varying the fields of the main exciters. The excitation system is designed for a moderately high rate of response of the order of 100 volts per second. Parallel fields on the main exciter are used to produce that response. An auxiliary field, in which the excitation may be reversed as desired, is provided in each exciter to take care of sudden major changes in voltage. The excitation of each unit is controlled by a high-speed voltage regulator.

Control

In this station 250-volt control is employed. Duplicate batteries, each with an 8-hr discharge rate of 95 amp to 1.75 volts per cell, are provided. These are equipped with a tap to permit their use for 250/-125-volt auxiliary lighting. Normally, one battery is used for control, the other for emergency lighting and other miscellaneous d-c requirements.

Switching and control for batteries and chargers, and switches for d-c distribution are housed in a dead front steel switchboard. D-c distribution at the main switchboard is handled from duplicate control buses through dead front disconnecting fuses housed in distribution cabinets.

Main Ground System

The island in the middle of the river offered an excellent location for ground electrodes, but it was a considerable distance from the power house. However, 4 ground mats, each consisting of approximately 20 rods connected to 2 500,000-cir-mil cables by a network of 4/0 cable, were located on this island; single lengths of 500,000-cir-mil cable, 300 ft long, were placed along the face of the dam. Inasmuch as this entire area is submerged, great care was taken to braze all joints thoroughly, and to break the network into several parts, the terminals of which were brought in through the face of the dam and connected together inside by 2 500,000-cir-mil cables running through the inspection tunnel. The loss of one or more of these incoming feeders from the network should not reduce seriously the protective value of the ground.

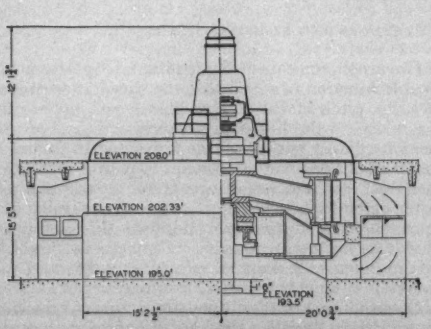

Fig. 7. Cross-section through a main 60-cycle generator

To obtain a direct path for lightning arrester grounds, several 1,000,000-cir-mil cables were carried from the lightning arrester location on the roof, out into the forebay, and terminated in connections to heavy rail sections. These cables were connected to gate guides and other submerged metal passed on the way to the forebay. It is expected that the amount of contact surface offered will give a fairly low resistance.

At the shore end of the power house directly adjacent to the rock fill on the railroad is a section of quiet water. It is expected that considerable silting will take place at this point; therefore, a network of cables, with a backbone of 500,000-cir-mil feeders, is laid there.

Two 500,000-cir-mil cables join the ground mats on the island with those in the forebay and those in the shore end of the forebay. In addition, heavy 5 x $^1/_4$-in. copper buses in parallel with these cables connect all grounds in the power house area. From these heavy buses are run auxiliary grounds to all sections of the station. Transformer banks are connected directly by short loops to the cables from the lightning arresters to the forebay. Transmission line ground wires are tied to the power house grounding system at several points in the vicinity of the power house.

Communication

A Bell telephone system with a central exchange located in the control room is used for telephone communication throughout the power house. This is supplemented by an autocall system with stations throughout the power house, dam, and substations, and by an operating-order signal-system between switchboard and turbine gage boards on the operating floor. To advise the operating staff of unusual operating conditions, a system of telephone annunciator drops is used.

Relays

Both the main and house generators are equipped with differential relays which shut down the unit completely. They are equipped also with overspeed and over-voltage relays with contacts in series. These act to open the main and field breakers and to bring the unit to rated speed with no load.

Provision is made for differential protection on the main buses; however, this protection is not yet installed.

Main transformer banks are equipped with differential relays, which protect a zone between the high-voltage bushing current transformers and the low-voltage bus. The 230-kv transformers are equipped in addition with a high voltage winding differential scheme.

As each of the main transformer banks is connected directly to a line, line and transformer pro-

tection is somewhat correlated. High speed impedance relays are used as protection against phase-to-phase faults. These are backed up by straight overload relays. Inasmuch as there are at present no high voltage buses on the system, ground protection is secured by the use of relays connected in the neutrals of the power transformers.

Main Turbines

An outstanding feature of the plant is the Kaplan turbines, the blades of which are adjusted automatically as the load changes, to maintain high efficiency over a wide range of load; also, the relation between blade angle and gate opening can be varied manually to compensate for changes in head.

[Editor's Note: For details of the design and setting of these turbines see "Kaplan Turbines for Safe Harbor Hydroelectric Plant," by Davis and Spaulding, Electrical Engineering, October 1932, p. 728–33.]

Selection of this type of turbine followed an extensive investigation covering turbine units equipped with the 4 principal types of runners, namely, the Francis type, the propeller high speed type with fixed blades, the propeller high speed type with manually adjustable blades, and the Kaplan high speed type.

To eliminate the objection of poor economy under varying loads, an investigation was made of the use of one Kaplan unit with governor adjusted runner blades, in combination with 5 propeller fixed blade runner units. The horsepower-efficiency characteristic of the Kaplan runner is quite flat and, consequently, high efficiencies are maintained as the load on the unit is reduced. With such a combination of units, and with the propeller fixed-blade runner units all operating at best efficiency and the Kaplan unit taking the load swings, reasonably good economy in the use of water may be secured.

Kaplan runners with their adjustable feature may be operated with the blades wider open than the fixed blade position on the propeller runner. Consequently, for a given wheel diameter, the Kaplan runner will have a higher maximum power, or, with the same power, a smaller runner diameter with a corresponding reduction in the spacing between units may be secured. The higher capacities are, of course, contingent upon the runners being set sufficiently low for these capacities to fall within the power limits set by cavitation.

For small turbines the difference in first cost between Kaplan turbines and turbines with fixed blade runners is appreciable; as the turbine size increases, however, the percentage difference becomes less, and for units of the size selected for Safe Harbor, becomes small and is practically negligible compared with the total cost of the development. As the units in this station are required to furnish energy over 2 separate systems, it was decided that at least 2 Kaplan units should be installed for each system group, so that one will be available at all times for economical regulation of the load should the other unit be out of service. In addition to the foregoing, certain other advantages accrued from the use of *all* Kaplan turbines with automatically adjustable blades as finally selected for this plant. These are the highest powered Kaplan turbines in the world; the runners are 220 in. in diameter, and will discharge about 9,000 cfs at full gate and normal head.

Two means of unwatering the wheel casing have been provided. In one scheme the tailwater can be lowered automatically by admitting compressed air to the wheel casings. As the gates on these units approach the no-load position, an air valve will open and admit compressed air to the wheel casing. If the gates are closed, as when running reserve, or as a synchronous condenser, air pressure will be maintained automatically in the wheel casing and will depress the water level below the runner. The alternative method of unwatering the turbines for inspection or maintenance is to put stoplogs in the discharge end of the draft tube and pump out the water with portable 10,000-gpm unwatering pumps.

Speed rings are of cast iron in 4 sections, containing a total of 20 stationary vanes cast integrally with the upper and lower rings; the over-all diameter is approximately 28 ft 10 in. The speed ring and stationary speed ring vanes are cored hollow, and provision has been made for introducing steam inside the vanes as a protection against the accumulation of frazil ice. Provision also has been made for the discharge of steam into the scroll cases, after these passages have been unwatered, to aid in dislodging any frazil ice which may have formed, and to sterilize the wheel pits.

Turbine guide bearings are of the babbitt lined, oil lubricated type. One belt driven pump is used to circulate the oil in normal operation. A motor-driven pump also is installed to start automatically through the action of a flowmeter should the flow of lubricating oil in the supply line be reduced to the minimum quantity required for proper lubrication.

Turbine operating mechanism consists of 20 movable cast steel gates actuated through 2 oil pressure cylinders connected to the gates through an operating ring and suitable links and levers. This mechanism is protected from injury by the use of shearing pins inserted through the upper and lower sections of the gate lever, one section of which is keyed to the gate stem.

Governors and Pumping Systems

Governor equipment is required to perform the double function of regulating the speed and controlling the pitch of the runner blades. Consideration was given to the following features: degree of protection against outage of the units due to failure of any part of the governor system; sensitive regulation of speed; convenience in operation; space required. After carefully considering 3 types of governing systems, the twin system was adopted; this system includes for each pair of units: 2 governors, 2 motor-driven pumps, 2 pairs of pressure tanks, and one common sump tank with 2 compartments.

Governors are of the oil pressure actuator type with motor-driven flyballs; they are of light construction, a desirable characteristic for sensitive operation and quick response to changes in speed.

Pumps are of the herringbone gear type, motor driven. This equipment is interconnected so that one pump may be used for the operation of either one or both of the main units and the second pump held in reserve as a spare unit. Each pump is equipped with a pressure starting switch to provide for the automatic starting of the pump held in reserve should the pressure in the supply tanks fall below the minimum pressure limit setting for the first pump. Unloader valves are installed to permit continuous operation of these pumps, if desired, in which case the oil will be by-passed automatically to the sump tanks when no additional fluid is required in the pressure tanks. Should it be found desirable to take either pair of pressure tanks out of service at any time, the pipe connections are such that both main units may remain in service, with one on governor and the other on hand control.

With this arrangement of equipment, a high degree of protection against outage is obtained, as the 2 main units served by each system may continue to operate with any one piece of governor system equipment temporarily out of service.

Each governor is equipped with a safety shutdown torque motor and solenoid switch, to provide for automatic closure of the turbine gates, to either the speed no-load or completely closed position through the operation of any one of several protective relays. Characteristics of the torque motor are such that it will not permit the opening of the turbine gates beyond speed no-load position until the voltage has reached from 50 to 60 per cent of normal (at which voltage the flyballs will assume control) except by hand through the release of a mechanical lifter. It is designed, also, to prevent the gates from opening when starting up should one phase of the three-phase governor flyball motor circuit be open. After the motor has been placed in service, the gates will be closed automatically when voltage drops to approximately 40 per cent of normal, but will remain open with one of the 3 phases of the governor supply open, should the voltage remain approximately normal. Governor flyball motors are driven from the pilot exciters on the main unit shafts through slip rings, and operate at 163 volts, 7.27 cycles.

Movement of the turbine blades is accomplished through a piston in the shaft cylinder, which is connected with the operating mechanism in the runner hub through a vertical rod within the turbine shaft. The piston is operated under oil pressure admitted to and discharged from the cylinder through 2 concentric pipes within the generator section of shaft. For every position of the turbine gates, the runner blades are moved to a corresponding position to develop the best turbine efficiencies through a wide range of load. The flow of oil to and from the shaft cylinder is controlled by a valve connected through a cam to the turbine gate operating mechanism. The relation of the turbine gate openings to the position of the runner blades is allowed to remain fixed within approximately a 4-ft variation in head. Beyond this range other cams, which may be quickly and conveniently shifted into position, are employed to insure reasonably high efficiencies under a wide variation of head.

A Résumé of Progress in Insulation Research

Steadily pioneering uncharted paths, the continuing efforts of those directing and participating in the uncovering and correlation of new knowledge in the field of dielectrics are laying foundations for the further development of electrical apparatus. A brief insight into some of these activities is given here.

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AS IN PRECEDING years, principal attention in this brief presentation is devoted to a survey of the literature of dielectrics and insulation as it has come to attention during the past year. Comments are based upon the reading of some 30 or 40 scientific papers, a list of which may be found at the close of this article. Since the topics vary over the whole field, from basic theory to large scale applications, the difficulty of a systematic division and the impossibility of anything more than a passing comment on the most important aspects of all this work may be appreciated.

Gases

An important series of optical studies of the beginning of spark discharge is reported by Lawrence and Dunnington. Using a Kerr cell between crossed Nicol prisms, photographs of sparks 4×10^{-8} sec after the application of voltage, as well as measurements of the broadening of spectrum lines and of the instantaneous current and temperature, have shown current densities of 1.7×10^{6} amp per sq cm in the spark; have revealed inter-ionic fields of 10^{6} volts per cm, and the ionization of $^{1}/_{3}$ of the total number of molecules; and have shown temperatures of the order of 10,000 deg K in the spark. These results support Slepian's theory of thermal ionization.

By experiments in a uniform field Inge and Walther have studied the flashover of solid insulators. It is stated that flashover is always a breakdown of the air. This breakdown is influenced, however, by moisture or other condition of the solid surface, through auxiliary ionization and unequal potential gradient; clean, dry surfaces in a uniform field

Essentially full text of a report presented to the fifth annual meeting of the N. R. C. committee on electrical insulation by Doctor Whitehead as its chairman, Baltimore, Md., Oct. 11, 1932.

flash over at the same voltage as the air when the dielectric is removed.

Interesting results on the decomposition of gases under electrical discharge are reported by Linder and Davis. Under glow discharge it is found that in a series of similar hydrocarbon compounds of increasing molecular weight the rate of gas evolution per unit current increases with the molecular weight, whereas in a series of the same molecular weight it increases with decreasing centralization. In another paper the ionization and dissociation of benzene and carbon-bisulphid under electron impact have been studied by spectrographic methods. Interesting data are recorded as to the nature and numbers of the resulting ions and conclusions are reached as to the stability of the bonds in the original molecule. These experiments have as their ultimate object the determination of information as to the chemical reaction in electrical discharges, with particular reference to the causes of the generation of gas in high voltage impregnated paper cables.

Liquids

The outstanding contribution in the field of liquid dielectrics is a series of 6 or more papers by A. Nikuradse, of the Technische Hochschule of Munich, concerning ionization, conductivity, and breakdown in insulating oils. These papers for the most part center about careful observations of the current-voltage curves under controlled conditions, and of similarly controlled breakdown tests over a wide range of frequency as related to the same oils. Good evidence is produced that the continuous current-voltage curve is of the same shape as that pertaining to gases. The saturation region is shown clearly, and in particular the ascending portion of the curve at higher voltages has been examined over a wide range of conditions. Temperature variations in the curves, and the increase of current with increased distance between electrodes, permit the computation of ionization coefficients and strengthen the theory of secondary ionization as the underlying cause of breakdown. In these experiments, purification was accomplished by drying, filtration, and successive distillation in an unusually elaborate experimental set-up. A definite residual conductivity always was found. The saturation phenomenon remains, and there are evidences of space charge of other polarity effects as related to the shape and materials of the electrodes. In the work on breakdown, one of the most striking features is the great increase in dielectric strength that may be reached by purification, this increase being of the order of from 100 to 1,000 times the values commonly attributed to good commercial insulating oils. The purer the oil, the less the influence of both pressure and temperature. For decreasing time of voltage application, the breakdown voltage for both pure and impure liquids approaches the same value, 1.3×10^6 volts per cm, at an impulse voltage of duration of the order 10^{-10}. The influence that air in solution in an insulating oil has upon the behavior when electric stress is applied has been studied by Koppleman. Data on the relation to breakdown are submitted.

It should be noted that in this work Nikuradse has not studied the question of behavior under alternating stress except in the matter of breakdown. The continuous current-voltage relations are those pertaining to the long time or steady state. Current and loss relations under alternating stress are associated with an initial or short time value of conductivity that may be quite different to that observed in the steady state under continuous potential. The steady alternating behavior as related to this type of short time conductivity has been continued at Johns Hopkins using several highly refined and carefully protected oils of the commercial insulating group. It has been shown that in the low range of frequencies the losses and power factors of these oils are completely accounted for by an initial value of d-c conductivity having a duration of the order of one second. The conductivity is clearly ionic and there appears to be no reason to invoke any type of loss other than that due to the friction of ionic translation within the liquid.

Several studies of refined insulating liquids in small cells having as their object the correlation of molecular and electrical performance are known to be under way, but no important results have been reported during the year.

Action of cathode rays on hydrocarbon liquids has been studied by Schoepfle and Fellows, and in other experiments in the laboratories of the Detroit Edison Company. The gaseous products of several hydrocarbons under fixed conditions of bombardment are reported. Certain correlations have been found between the amount of gas and the molecular structure. Saturated hydrocarbons give large amounts of gas, whereas unsaturated hydrocarbons give small amounts of gas. Aromatic hydrocarbons give practically no gas. These experiments are directed particularly toward the conditions underlying the liberation of gas in high voltage cables, and seek information as to the relative stabilities of various oils under electric influence.

Solids

Most of the contributions in connection with solid dielectrics have a theoretical trend. P. Böning has continued his contributions expounding his theory of adsorption by colloid particles of the ions of one sign, and the passage to the electrodes of the ions of opposite sign, thus creating space charges and high values of potential gradient. The theory is developed particularly for liquid insulators, but is extended to include impregnated materials and others in which the liquid phase obtains to some extent. The most recent contribution deals specifically with the application of the theory of the behavior of impregnated paper, with particular consideration of space charge and potential gradient.

In a paper entitled, "What Is an Insulator?" Meissner proposes that the characteristic properties of insulators lie in the elementary crystal cell. The influence of the type of lattice, the nature of the bonds, and the intensities of the fields are discussed and correlated with experiments on piezo and pyro phenomena in crystalline and amorphous quartz.

The behavior of complex dielectrics also is discussed and the statement made that these, in general, if fused and allowed to solidify while under electric stress, also will show the pyro and piezo effects.

Debye's theory of molecular orientation as an explanation of dielectric loss in solid and semi-solid materials continues to be a topic of interest. An interesting series of experiments carried on by H. H. Race on electric and other physical properties of insulating oils, notably of oxidation and the spread of oil on water, support only partially the explanation of dielectric loss as a Debye effect. Oxidation increases the loss, but not the frequency at which maximum occurs. However, the spread on water is increased and this is an evidence of a polar property. A substantial loss factor remains after the computation of the Debye loss, indicating some other loss.

Measurements of dielectric constant and power factor of rosin oil and ethyl abietate in the range of frequency from 10 cycles to 100 kc and over the temperature range from -65 to $+20$ deg C, and other measurements made on certain glycols in the frequency range from 1 to 100 kc and with temperatures ranging down to -90 deg C have been made by White and Morgan. The particular interest of these substances is that their viscosity increases greatly within the temperature ranges mentioned, so that the anomalous dispersion or change of dielectric constant and also the maxima of power factor may be traversed into the measurements. Good agreement as between experiment and the Debye theory was found for a pure glycol, but some divergence in the case of a solution. Similar qualitative agreement was found by the same authors in rosin oil. At Johns Hopkins, experiments have shown that in the low frequency (60 cycles) range the observed variation in power factor and capacitance or dielectric constant with temperature may be accounted for in terms of a polarization arising first in the separation of space charges and later, as the solid phase is approached, in terms of the Maxwell dielectric absorption. So far as the losses in well known insulating liquids and in the more complex combinations for commercial insulation at 60 cycles are concerned, there seems to be general agreement that types of polarization other than that due to molecular orientation are well recognized, and under the Maxwell-von Schweidler theory of dielectric absorption are sufficient to account for the observed values of power factor and dielectric constant and their variations. If polar molecules are present, their contributions to these variations probably are small. At present, the most promising means of distinguishing between these two effects is to find a material in which there are two regions where the dielectric constant changes with frequency. In fact, Gemant has called attention to the fact that three such regions are to be expected, the third region being that of normal or optical dispersion due to the inertia of the charges within the body of the atom. Gemant places the range of frequency for the Maxwell-Wagner power factor maximum and corresponding anomalous dispersion at from 1 to 10^8 cycles, whereas the Debye region is from 10^8 to 10^{12}, and the inner atomic region is around 10^{14} cycles.

The mechanism of the breakdown in solids has been discussed in an extensive paper by Joffé in which he includes brief accounts of many experiments which heretofore have been published only in Russian. They are now and will be in the future available in the Physikalische Zeitschrift der Sowjetunion, which is printed in German. Experiments are reported indicating that the breakdown voltages of natural, carefully tempered, and strongly deformed rock salt, colored by exposure to Röntgen rays, were found to be identical for impulse and continuous voltages, a result which the author feels proves that internal crystal cleavages have no bearing upon the mechanism of breakdown, just as the same author has shown that they have no influence upon the electric conductivity. Ionization by collision is studied in thin layers, in which case the ionization leads to a stationary current easily measured, instead of to breakdown. This peculiarity of thin layers is related intimately to their higher dielectric strength. As observed in mica and glass in layers 0.005 mm thick, dielectric strengths of 50×10^6 volts per cm were reached. The same phenomenon also was observed in pure gas-free liquids. Whereas, in thick layers, breakdown due to impulse or collision ionization is independent of the temperature, in thin layers the breakdown voltage is lowered with rising temperature until it reaches the thick layer value at the temperature of thermal breakdown. These facts lead to the conclusion that impulse ionization is caused by mobile ions and not in any way by electrons due to radio active influence. Nevertheless, it seems to indicate that an avalanche of ions leads to breakdown when the necessary initial conditions for thermal breakdown are present. The increased conduction due to ionization by collision, if not carried to breakdown, vanishes very quickly. In thin mica the recombination time is less than 0.003 sec.

Commercial Insulation

From a great deal of experimental and development work in this field, space limitations permit the mention of only 1 or 2 examples that are of particular significance. Gemant has proposed a new theoretical analysis of the rising power factor-voltage curve for impregnated paper containing gas layers. It is based upon the assumption that the breakdown of a thin air layer is limited to about 350 volts and that after breakdown the difference of potential over the air layer becomes zero and the ionization current stops. Further discharge can take place only by further increase of the applied over-all voltage or by its reversal. Thus, during the alternating cycle of maximum value just sufficient to cause breakdown, there will be 4 such breakdowns in one cycle. If the applied voltage is double or three times that necessary to cause the first breakdown, the number of discharges will be 8 and 12, respectively, etc. The author attempts a mathematical extension of this idea to the general case as based on thermal relations. The curves as derived agree generally with those observed, and the author claims that the usual power factor-voltage curve as measured may, by use of his

formula, be used as an indication of the density of air layers within the insulation.

Whitehead and Baños, working with 10 different insulating oils, have shown that the dielectric loss in impregnated paper consists of 2 components, one due to conduction and the other to dielectric absorption; and further that a general relation exists between each of these components of loss, and the common physical properties of the impregnating oil. Baker and James have shown in qualitative manner the existence of soft X-rays and unequal potential distribution in impregnated paper. Wood and Brobst have reported the treatment of textile insulation with cellulose acetate, with resulting lowering of leakage conductance, the action apparently being due to the laying down of the fibers.

High Voltage Cables

A great deal of experiment and observation on cables, both in service and in laboratories, is being conducted by prominent utility companies. These studies have to do largely with the influence of temperature cycles on loss and power factor as related to stability, and in several instances are paralleled by accelerated life tests. Particular attention is being given to the performance of oil filled cables, and to the question of the possible reduction in thicknesses of insulation. Other questions receiving attention are a suitable aging test, the deterioration of impregnating oils under electric discharge, the thermal resistivity of insulation, and the imperfections of lead sheath due to corrosion and other causes. Reports of these various studies are commonly circulated within the N.E.L.A., the Association of Edison Illuminating Companies, and the bulletins of the Electrical Testing Laboratories. These reports are familiar to many persons, and as they are not published no attempt has been made to record them in detail in this report. An interesting survey of modern design, construction, and operation of high voltage cables will be found in a group of papers presented to the International Electrical Congress in Paris this last summer.

Monographs

While the issuance of another monograph has been impossible during the year just closing, substantial progress has been made toward the completion of further volumes in the series of monographs on dielectrics and insulation to be published under the auspices of the National Research Council's committee of electrical insulation. The first in the series, as may be remembered, was "The Nature of a Gas," prepared by Prof. L. B. Loeb of the University of California, Berkeley, Calif. The manuscript of the second in the series—"Liquid Dielectrics," by Dr. Andreas Gemant—is in hand and now is in process of preparation for publication. Progress is being made on 5 additional monographs:

Electric Discharge in Gases, by K. T. Compton and Irving Langmuir

Conduction in Gases, by J. Slepian and R. G. Mason

Solid Dielectrics, by C. F. Hill

Electrical Properties of Glass, by J. T. Littleton

Chemical Effects in Electric Discharge, by Geo. Glockler and S. C. Lind

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Out-of-Step Conditions on a Synchronous System

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During out-of-step conditions on a synchronous system a state of equilibrium may be reached under which the system will neither accelerate nor retard until conditions are changed by switching operations or by removal of synchronous condensers. Proof of this theory is given for a condition where the synchronous condensers were operating at 35 cycles (70 per cent of normal), the generators at normal speed of 50 cycles, and induction motors, with a load varying as the square of speed, operating at 65 per cent of synchronous speed.

ON SEVERAL OCCASIONS it was observed that when out-of-step conditions exist on the system of the Southern California Edison Company, Ltd., the synchronous condensers slow down to about 35 cycles per second and run at that speed until switched off the line or until operating conditions are altered in some other way. To determine the proper procedure for quick restoration of synchronism an actual out-of-step condition was exhaustively analyzed; the results of that analysis are given in this article. For some time several methods have been available for determining the power limits of a transmission system under steady state and transient conditions, but little is known of the behavior of systems when definitely out of step. The subject of system stability as presented up to this time has been treated as a problem of *maintaining* stability, whereas this article gives prime attention to the problem of *regaining* stability.

Synchronous Power

The first step in evolving a method of solution was to consider the power equation of a synchronous machine:

$$P_m \sin \delta + P_r = P \qquad (1)$$

In this equation, which is accurate enough for the purpose involved, the terms representing electrical power are grouped on the left side of the equation and are equal to P, which is mechanical power. The term P_m is the maximum synchronizing power that can be exchanged between the generator and the equivalent synchronous machine, which represents all the remaining synchronous machinery of the system. P_r includes the internal losses and power supplied to resistance loads. Synchronism will be lost when the angle δ exceeds 90° and $P_m + P_r$ becomes equal to or less than P. From then on the synchronous power P_m alternates from positive to negative. The net power applied to the rotating parts of the generating unit is equal to the algebraic difference of the 2 sides of eq 1. This is shown in Fig. 1.

In most cases P_m is larger than P_r; hence when δ reaches the magnitude of 270° the left side of eq 1 becomes an input of power from the slower system to the faster generator. It can be shown that if P could be made equal to P_r during out-of-step conditions, the generator would continue to run at some average constant speed, but out of synchronism. Were P reduced to a value lower than P_r, the generator would retard and eventually fall in step with the system. This reduction of P is effected by the governor of the prime mover, but is not fast enough to prevent considerable disturbance of the system.

Inertia

However, eq 1 is true only under normal operating conditions and approximate for small deviations from synchronous speed. An important term has been omitted in the foregoing discussion that must be introduced into the equation when transients and out-of-step conditions are being investigated. The net power applied to the rotating parts of the generating unit has been mentioned already. Power applied to a rotating body having a certain angular

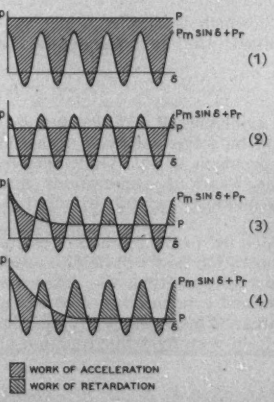

Fig. 1. Input and output of a synchronous generator when running out of synchronism expressed as functions of angle between internal voltages of the generator and the combined synchronous machinery

1. P larger than $P_m + P_r$
2. P smaller than $P_m + P_r$ but larger than P_r
3. P is made equal to P_r
4. P is made smaller than P_r

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momentum (sometimes called moment of momentum) will cause acceleration or retardation, depending upon the direction of the power applied. Either the generator or the system can be taken as a reference and a relative inertia term assigned to the other. Remembering further that the relative acceleration of the 2 is the second derivative of their angular displacement, eq 1 can be expressed as follows:

$$P_i \frac{d^2\delta}{dt^2} + P_m \sin \delta + P_r = P \qquad (2)$$

This equation represents synchronous machines with very little damping or induction motor characteristics; for transient stability calculations at or near synchronous speed, it is being used in this form or its equivalent in torque terms.

Induction Machine Characteristics

Synchronous machines have some damping as an inherent characteristic in addition to the damping introduced into their design to stabilize them in operation and to improve their starting characteristics. Damping is equivalent to the induction machine characteristics that exist in the field structure of the synchronous machine. A certain amount of damping is introduced by the field circuit itself when completed through the armature of the exciter, by the damper windings when present, and by the iron of the field structure. As in induction machines, the power due to damping is a function of terminal voltage and difference of speeds or the first derivative of angular displacement. By introducing the damping term in eq 2 the following equation is obtained:

$$P_i \frac{d^2\delta}{dt^2} + P_d \frac{d\delta}{dt} + P_m \sin \delta + P_r = P \qquad (3)$$

This is the general equation of a synchronous machine and its development is described by W. V. Lyon and H. E. Edgerton, in their paper "Transient Torque-Angle Characteristics of Synchronous Machines" (A.I.E.E. Trans., v. 49, April 1930, p. 686–99.)

Out-of-Step Operation

Unfortunately eq 3, which is a differential equation, has not been solved; that is, presented in the form

$$\delta = f(t) \qquad (4)$$

Were such a solution available, all stability and out-of-step problems could be solved easily in terms of time. As it stands, problems of this kind must be dealt with by making various assumptions and approximations, or by making long and tedious step-by-step calculations.

The assumption which led to the method of calculation of out-of-step operation now will be discussed. As was observed in actual operation, the difference in speeds of generators and condensers was constant for a period of minutes. This being the case, the angle δ was assumed to be a straight line function of time $(Kt + \delta_o)$:

$$P_d K + P_m \sin (Kt + \delta_o) + P_r = P \qquad (5)$$

The average can be found by integrating with respect to dt between limits of O and $\frac{2\pi}{K}$ and dividing by $\frac{2\pi}{K}$. The final equation will be

$$P_d K + P_r = P \qquad (6)$$

Equation 6 can be interpreted to mean that when a synchronous generator is out of step, and running at constant speed, the synchronizing power is pulsating and the average value is zero. The input then must be equal to the total of losses, resistance loads, and output as an induction generator. When a condenser or synchronous motor is out of step and running at a constant speed the mechanical output, losses, and electrical output due to internal voltage must be equal to the input as to an induction motor.

The assumption of δ being a straight line function of time is not correct in a strict mathematical solution, but a substitution of typical numerical values and a step-by-step solution would demonstrate the permissibility of that assumption, because the result is quite accurate for practical purposes.

Method of Computation

When machines of different characteristics are connected to the same system and are out of step, 2 or more frequencies are imposed on the system. The method of analyzing a condition of this kind is discussed in the following paragraphs.

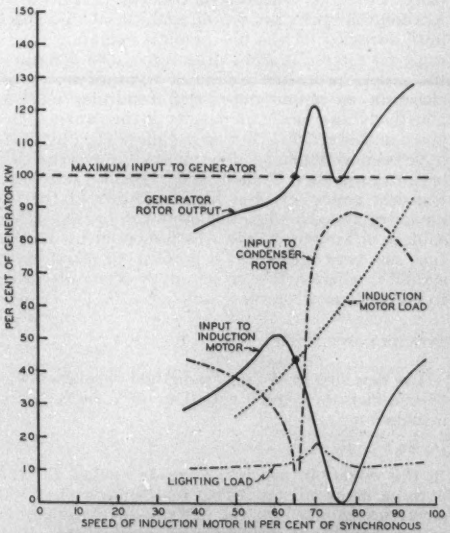

Fig. 2. Power input and output of machines expressed as functions of speed of induction motor

System consists of 200,000 kw of steam generating capacity, 240,000 kva of synchronous condensers, 190,000 kw of induction motor load, and 50,000 kw of resistance load. The generators are operating at normal speed while the condensers are operating at 70 per cent of synchronous speed

Consider a simple system composed of a generator, a short transmission line, a synchronous condenser with damper windings, an induction motor with a load varying as the square of its speed, and some resistance or lighting load. The generator is running at 50 cycles, the condenser at 35 cycles. The problem is to determine the speed of the induction motor and the power flow in the circuits. To do this, the 2 synchronous machines are considered as consisting of an ideal synchronous machine solidly coupled mechanically to an induction machine having characteristics similar to those of the original machine. Under normal synchronous operation both component machines would be connected to the same circuit and the induction part would be driven at synchronous speed with respect to the system thus having zero power output, but during out-of-step conditions 2 systems must be considered. One of these is a 50-cycle system composed of the synchronous generator supplying power to the induction motor characteristics of the synchronous condenser which is operating at a 30 per cent slip, in addition to the power required by the induction motor and resistance load; the other, a 35-cycle system composed of an induction generator operating at 43 per cent positive slip and supplying power to the induction motor and resistance load by virtue of the fact that the induction characteristics of the synchronous generator receive excitation from the synchronous condensers at 35 cycles. Power inputs and outputs of the units in both systems can be computed and the results superposed. The results then are plotted as functions of induction motor speed.

In Fig. 2 are shown results of computations of a condition experienced on a portion of the system of the Southern California Edison Company, Ltd., after an out-of-step condition had occurred and the system had been separated into 3 independent sections. The section under consideration included 200,000 kw of steam-electric generating capacity, 240,000 kva of synchronous condensers, a normal 190,000 kw of induction motor load, and 50,000 kw of resistance load. The speed of the generators at the time represented in Fig. 2 was normal, but that of the condensers was observed to be but 70 per cent of normal, or 35 cycles per second. As may be seen from Fig. 2 the induction motor was running at about 65 per cent of synchronous speed, as the dual frequency input at that speed balanced the load. The induction motor load under these conditions amounted to 44 per cent of generator input or 88,000 kw, the lighting load amounted to 12 per cent of generator input or 24,000 kw, and the bus voltage was 69 per cent of normal. The remainder of the generator input was absorbed in generator, transformer, line, and condenser losses. The generators were carrying full load and could not develop any additional power to accelerate either the condensers or the induction motors. The induction motors did not slow down because at lower speeds their input would have exceeded their load.

With conditions of this kind established on the system it is necessary to switch the condensers off until after the induction motors are accelerated to normal speed with respect to the generators. Then the condensers can be resynchronized. If the system be allowed to operate for any length of time under conditions like those just described the condenser and generator damper windings and field structures will overheat rapidly and eventually burn out.

Details of Calculation

Some of the details of calculating out-of-step conditions are indicated in the following brief outline.

Nomenclature:

E_1 —internal voltage of generator
E_2 —internal voltage of condenser
$\dot{Z}_1$ —impedance of generator to bus
$\dot{Z}_2$ —impedance of condenser to bus
V —bus voltage
R —resistance shunt
$\dot{Z}_1''$—impedance of equivalent induction generator driven at f_1 cycles on an f_2-cycle bus
$\dot{Z}_3'$—impedance of induction motor at speed S_3 on an f_1-cycle bus
$\dot{Z}_3''$—impedance of induction motor at speed S_3 on an f_2-cycle bus
$\dot{Z}_2'$—impedance of synchronous condenser at speed f_2 cycles on an f_1-cycle bus
$\dot{Y}'$ —total admittance of circuits at f_1 cycles from air gap of generator
$\dot{Y}''$—total admittance of circuits at f_2 cycles from air gap of synchronous condenser

There will be 2 electromotive forces in the circuit. If f is the normal frequency,

$$E_1' = \frac{f_1}{f} E_1 \quad \text{and} \quad E_2'' = \frac{f_2}{f} E_2$$

The generator output will be

$$P_1 + jQ_1 = \frac{f_1}{f} \dot{E}_1 \dot{V}' \dot{Y}' - \frac{(V'')^2}{\dot{Z}_1''}$$

Condenser input (or output)

$$P_2 + jQ_2 = \frac{f_2}{f} \dot{E}_2 \dot{V}'' \dot{Y}'' - \frac{(V')^2}{\dot{Z}_2'}$$

Induction motor input

$$P_3 + jQ_3 = \frac{(V')^2}{\dot{Z}_3'} + \frac{(V'')^2}{\dot{Z}_3''}$$

Resistance load

$$P_4 = \frac{(V')^2 + (V'')^2}{R}$$

Bus voltage

$$\dot{V}' = \frac{f_1}{f} E_1 - \left(\frac{f_1}{f}\right)^2 E_1 \dot{Y}' Z_1$$

$$\dot{V}'' = \frac{f_2}{f} E_2 - \left(\frac{f_2}{f}\right)^2 E_2 \dot{Y}'' \dot{Z}_2$$

The problem then consists in evaluating the impedances and admittances of the circuits, using all available data on machinery or making reasonable assumptions.

Generator input $= \dot{P}_T$ (constant)

Motor load $= P_L S_3^2$ where P_L = coefficient.

Proof of Superposition Principle

If 2 frequencies having a ratio r

$f_1/f_2 = r$

are considered and expressions for instantaneous voltage and current in one phase to ground of the circuit are written

$$e_1 = E_1 \sin (r\omega t)$$
$$e_2 = E_2 \sin (\omega t)$$
$$i_1 = I_1 \sin (r\omega t + \theta_1)$$
$$i_2 = I_2 \sin (\omega t + \theta_2)$$

the powers (1 phase) are

$$P_1 = \frac{1}{2} E_1 I_1 \cos \theta_1$$

$$P_2 = \frac{1}{2} E_2 I_2 \cos \theta_2$$

and it is to be proved that

$$P_R = P_1 + P_2$$

The resultant voltage and current in the circuit are

$$e_R = E_1 \sin (r\omega t) + E_2 \sin (\omega t)$$
$$i_R = I_1 \sin (r\omega t + \theta_1) + I_2 \sin (\omega t + \theta_2)$$

and the instantaneous power is

$$P_R = e_R i_R = [E_1 \sin (r\omega t) + E_2 \sin (\omega t)] \\ [I_1 \sin (r\omega t + \theta_1) + I_2 \sin (\omega t + \theta_2)]$$
$$P_R = E_1 I_1 \sin (r\omega t) \sin (r\omega t + \theta_1) + E_2 I_2 \sin (\omega t) \sin (\omega t + \theta_2) + E_1 I_2 \sin (r\omega t) \sin (\omega t + \theta_2) + E_2 I_1 \sin (\omega t) \sin (r\omega t + \theta_1)$$

Remembering that

$$\sin \alpha \sin \beta = \frac{1}{2} \cos (\alpha - \beta) - \frac{1}{2} \cos (\alpha + \beta)$$

we now have

$$2P_R = E_1 I_1 \cos \theta_1 + E_2 I_2 \cos \theta_2 - E_1 I_1 \cos (r\omega t + \theta_1) - E_2 I_2 \cos (\omega t + \theta_2) + E_1 I_2 \cos (\theta_2 + (1 - r)\omega t) - E_1 I_2 \cos (\theta_2 + (1 + r)\omega t) + E_2 I_1 \cos (\theta_1 + (1 - r)\omega t) - E_2 I_1 \cos (\theta_1 + (1 + r)\omega t)$$

The average value of power is

$$P = \frac{1}{T} \int_0^T eidt$$

Let O and T satisfy the equation

$$\sin (\omega t) = \sin (r\omega t) = 0$$

and integrate the expression for $2P_R$. The process of integration is too complicated to show here, but the result is

$$2P_R = E_1 I_1 \cos \theta_1 + E_2 I_2 \cos \theta_2$$

and

$$P_R = \frac{1}{2} E_1 I_1 \cos \theta_1 + \frac{1}{2} E_2 I_2 \cos \theta_2$$

which is

$$P_R = P_1 + P_2$$

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A Theory of Neon Tube Operation

Here is advanced a theory of luminous tube operation based upon an engineering study of the voltage and current waves associated with the discharge of electricity through neon gas.

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SUCCESSFUL OPERATION of the popular cold cathode neon tube lighting system depends upon many factors, some of which are quite intricate and intangible. In this system a transformer which may have 97 per cent reactance and a secondary potential as high as 15 kv is used as a source of supply. The theory of operation of this system may be generally unknown, and it is the purpose of this article to promote a theory from an engineering standpoint based upon a study of the voltage and current waves associated with the discharge through the neon gas.

In its normal state neon gas is a relatively good insulator, but when ionized the gas becomes a conductor with a negative resistance characteristic. This means that the lower the voltage drop across a given length, the greater the current that flows through the gas. A volt-ampere curve of one particular type of neon tube is shown in Fig. 1. If the symbol e_t represents the instantaneous value of voltage it can be expressed as some function of the current, thus

$$e_t = f(i) \qquad (1)$$

If a sinusoidal current wave passing through the gas be assumed, and if from the instantaneous values of current are found the corresponding values of voltage, the wave form of voltage necessary to produce this current can be determined. Such a wave form is shown in Fig. 2. It is not feasible, however, for a sine wave of current to flow through the neon gas because the ionization potential as shown in Fig. 1 is higher than the voltage necessary to maintain a current flow. The potential at the beginning of each half-cycle must rise to a value sufficiently high for ionization, then reduce to some value indicated by the curve in Fig. 1. It is evident that the current

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must remain at zero for a short period of time during each half-cycle, and as a result the wave form is more peaked than a sine wave. The actual wave form of current and voltage is shown by the oscillogram in Fig. 3 which was obtained from a circuit employing a resistance instead of a reactance for limiting the current. This establishes 2 important facts: (1) that the current wave crosses the zero axis inside the

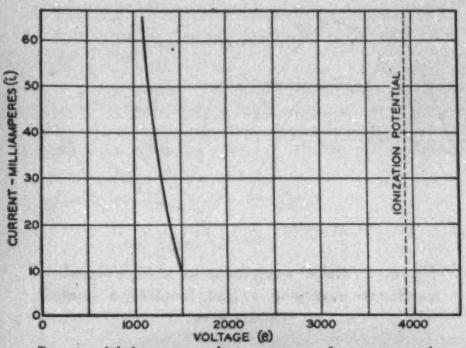

Fig. 1. Volt-ampere characteristics of one type of neon tubing including electrode and gas column

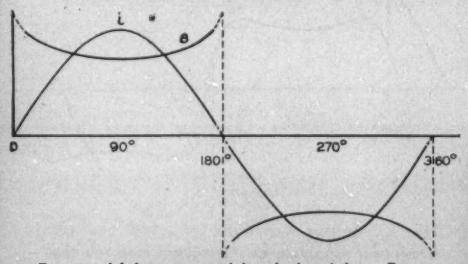

Fig. 2. Voltage wave (e) calculated from Fig. 1 assuming sinusoidal current (i)

envelope of voltage wave, and in this respect the neon tubing acts as a resistance load requiring peaked current; (2) during each half-cycle the current actually is zero for a finite length of time.

Consider a high reactance transformer as represented by the circuit in Fig. 4 which shows the reactance of a transformer concentrated in an inductance L in the secondary circuit. Neglecting the resistance drop in both the transformer and the external inductance the voltage across the resistance load may be represented by the equation

$$E_R = E_S - E_L \text{ vectorially} \qquad (2)$$

In eqs 1 and 2 the symbols E indicate rms values. If instantaneous values are considered,

$$e_R = e_s - e_L = e_s - L\frac{di}{dt} \qquad (3)$$

The vector and wave-form diagrams of Fig. 5 may represent, respectively, eqs 2 and 3, and from these diagrams it is clearly evident that the load voltage lags the induced or open circuit voltage by some angle ϕ. If the load is of such a nature that a peaked current wave is established throughout the circuit, the differential of this current wave represented by $L\frac{di}{dt}$ will be a flat topped wave. When this flat voltage wave is subtracted from the open circuit voltage e_s the load voltage wave e_R also will be a flat topped wave as shown in Fig. 6. Thus it is possible for the current to assume such a form that the load voltage wave will be somewhat similar to that shown in Fig. 2 and therefore suitable for operating a neon tube load, at least for a portion of each half-cycle. When a neon tube load is substituted for a resistance load, the symbol e_t should be substituted for e_R in eqs 2 and 3. Thus there are 2 equations (1 and 4) which must be satisfied by the same value of current:

$$e_t = f(i) \qquad (1)$$

$$e_t = e_s - L\frac{di}{dt} \qquad (4)$$

When the neon tube load is placed across the secondary of the transformer the current follows a periodic variation. The instantaneous values of current not only must give some specific value of e_t represented by eq 4, but the same instantaneous value of current must give the same value of e_t when taken from the curve in Fig. 1 or from eq 1. The actual wave form of current, therefore, will be a compromise between a peaked wave and a sine wave.

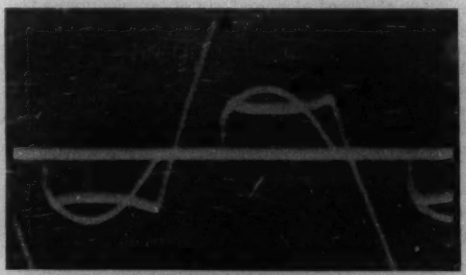

Fig. 3. Oscillographic record of current (a) in and voltage (b) across a section of neon tubing with current limited by resistance

Considering again the circuit which has wave form characteristics as indicated in Fig. 6, suppose the initial condition is open circuit, when only the voltage e_s exists; then let a load suddenly be applied and, for simplicity, assume that no oscillatory phenomena are involved. The terminal voltage must change from the open circuit wave form to the load voltage wave form which requires not only a change in magnitude, but also a change in phase relation.

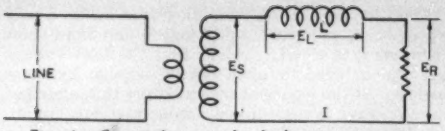

Fig. 4. Circuit diagram of a high reactance transformer with leakage reactance concentrated in a series inductance (L)

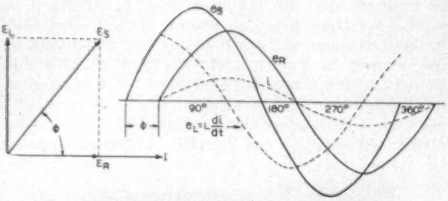

Fig. 5. Vector (left) and wave form (right) diagrams showing the relation of voltages for a high reactance transformer supplying a resistance load

Likewise, when the load is removed suddenly the voltage must transfer from the load voltage condition to that of open circuit voltage wave form. The terminal voltage will follow some form as generally indicated in Fig. 7. By further reference to Fig. 3 it is evident that, since the current is zero for an appreciable time during each half-cycle, the load is equivalent to one which is applied and removed at the beginning and end of every half-cycle.

Now, the general wave form of voltage across the terminals of a neon tube may be derived. If it be assumed that the neon tube load is applied to the transformer at the instant when e_s crosses the zero axis the voltage will rise along the open circuit wave until ionization occurs. After this value of voltage is reached the flow of current causes the voltage to drop rapidly to the load voltage wave form. This rapid decrease in voltage causes the current through the neon gas to increase to a greater amount; but an instant later the voltage will rise along the load voltage wave form, which rise must be accompanied by a decrease in current through the neon gas. This process is contrary to the normal tendencies of the current, which attempts to maintain a sinusoidal wave form. From the standpoint of eqs 1 and 4, the current flow during the initial portion of each half-cycle will not satisfy both these equations because of this unstable phenomenon which causes the voltage and current to continue to oscillate until finally a stable state is maintained. This general process is shown in Fig. 8. At the end of each half-cycle the load is removed and hence the voltage returns to the open circuit position which by this time already has crossed the axis and may be of sufficient magnitude in the opposite direction to cause instant re-ionization of the gas for the next half-cycle. In Fig. 9 is shown a cathode ray oscillogram of the unstable portion of a half-cycle. From this oscillogram one may come to the conclusion that the oscillatory period is similar to a damped oscillation which finally terminates in a stable condition.

When the length of tubing is increased the position of e_s in Fig. 8 and the ionizing potential shift to a higher value. It is possible to add such a length of tubing that at no time during the half-cycle will the current satisfy eqs 1 and 4, and the result is a continued oscillation throughout the entire half-cycle. This unstable phenomenon is accompanied by the appearance of a series of dark spaces (referred to as "beads") in the illumination emitted by the neon gas. By still further increasing the length of tubing the ionization potential may be increased to a value corresponding to the maximum value of the open circuit voltage wave. Occasionally this open circuit voltage may be insufficient to produce ionization, and for an entire half-cycle or longer no illumination will be produced. Such a condition is the cause of flicker. During this period the voltage simply follows the open circuit wave form until ionization is produced again, which may or may not be on the next succeeding half-cycle. In Fig. 10 is shown an oscillogram, made with a mechanical oscillograph, that represents the wave form of voltage showing 3 conditions: flicker, beads, and stable operation. A wave representing what the open circuit voltage would be if

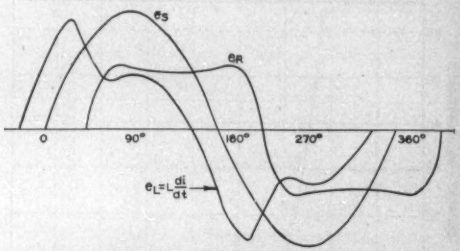

Fig. 6. Voltage wave forms for a high reactance transformer supplying a load requiring a peaked current wave

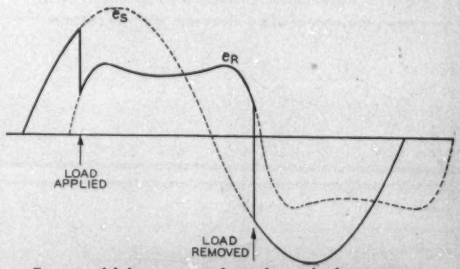

Fig. 7. Voltage wave form for a high reactance transformer supplying an intermittent load requiring a peaked current wave

there were no tubing connected to the transformer also is shown on the oscillogram. Too great a length of tubing places a severe strain on the transformer, especially if beads occur, because the high frequency oscillations are prolonged for an entire half-cycle and the peaks of these oscillations are near the peak of the open circuit voltage wave form.

Occasionally it happens that one user of a neon sign obtains better performance than another having the same type of transformer and the same kind and length of tubing. This difference in operation may be explained by the fact that the amount of capacitance from the tubing to ground may be different in the 2 installations. When a capacitor is placed across the terminals of a high reactance transformer the voltage is raised above the open circuit value. If the capacity is small, however, the amount of boost in voltage is small on open circuit, but with a neon tube load this capacitance is effective. The reason for this is that the rapid change in voltage at the end of each half-cycle, as shown in Fig. 8, is equivalent to a very high frequency under the influence of which the capacitor becomes effective in boosting this peak above the open circuit value. This is especially true for long lengths of tubing for which the ionization potential is near the peak of the open circuit voltage. By purposely adding capacity to the circuit, a greater length of tubing can be operated from a given transformer, but this is because the voltage rises above the open circuit voltage at the beginning of each half-cycle and therefore is undesirable from a standpoint of transformer life. To obtain successful operation from the transformer as well as from the neon tubing it is essential to operate the transformer with a length of tubing considerably shorter than that which will produce flicker or beads.

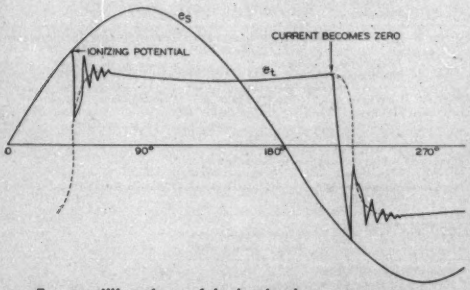

Fig. 8. Wave form of the load voltage across a neon tube

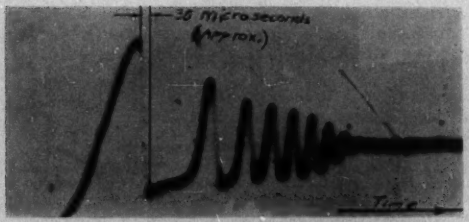

Fig. 9. A cathode ray oscillogram of a portion of one half-cycle of a neon tube voltage wave showing how the unstable portion is attenuated

Some of the most important factors affecting the operation of a neon lighting system arise from the characteristics of the tubing itself. Such factors as gas pressure; impurities in the gas; size, shape, and number of electrodes; diameter of tubing; and kinds of gases used to produce various colors have some influence upon the ionizing potential of a given length of tubing and upon the shape of its volt-ampere characteristic curve. One may realize that a change in the shape of the curve of Fig. 1 will influence eq 1; hence the duration of the unstable period of each half-cycle, and the magnitude and frequency of the oscillations during this period, will be different for each different type of tubing. A transformer of some specific rating may operate 70 ft of one type of tubing, whereas the same transformer might be under a more severe strain if loaded with only 40 ft of some different type of tubing, because of the possible occurrence of high frequency oscillations and of peaks higher than the open circuit voltage.

In the foregoing discussion many factors have not been considered; such as change in ionization potential with temperature of electrode, change in volt-ampere characteristics with temperature, deionization time of neon gas and others. No doubt many of these items should be taken into consideration in order to offer a complete explanation of the wave forms of voltage and current observed. However, the important point to bear in mind is that a study of the voltage and current wave forms of neon tubing presents a much clearer picture of the physical operation of this system of illumination than otherwise would be possible.

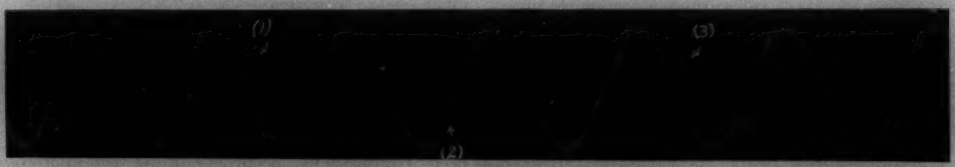

Fig. 10. Oscillogram of voltage across a neon tubing showing (1) a stable half-cycle, (2) a flicker period, (3) instability throughout one entire half-cycle

Experience With Supervisory Control

The Reading-Philadelphia suburban electrification has afforded a thorough trial of supervisory control equipment in actual operation. The experiences which have been secured with this equipment and which demonstrate its numerous advantages are described in this article.

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ALL substations and switching stations for the Reading-Philadelphia suburban electrification are non-attended and operated by supervisory control. This type of control was selected on the basis of flexibility, speed with which the system can be cleared at the time of fault, freedom from error, concentration of operation at one point, elimination of divided responsibility, and economy. Two men maintain the equipment which is installed in 21 stations. There has been no trouble experienced from induction, no faulty operations have been performed, no faulty indications have been given and not a single train delay has been caused by failure of the supervisory control equipment. Each benefit attributed to the equipment has been fully realized in operation, proving the adequacy of supervisory control for operating an electrified railway.

The power dispatcher's office is located at Wayne Junction, 5 miles from Reading Terminal, Philadelphia, Pa., as this is the junction of several branch lines and the location of the railroad's main substation. Here also, is the Philadelphia Electric Company's frequency-changer station which supplies the 25-cycle power for the electrification. Train dispatchers are located at Reading Terminal and a special telephone line connects the train dispatcher's office with the power dispatcher's office.

From his office at Wayne Junction the power dispatcher operates the entire system with supervisory control; he controls 8 main substations and 13 switching stations, including control and supervision of 255 points over 4 supervisory control systems, utilizing 4 sets of line wires. Table I indicates the various systems and summarizes the number of stations and control points on each set of line wires, one set of line wires being required for each system. It is of particular interest to note that on the Wayne Junction-Lansdale system there are 11 stations, all operated over the same set of line wires.

Table I—Summary of Supervisory Control Equipment

Station	Number of Points	Dist. from Disp. Office (Miles)
System A—Wayne Junction to Reading Terminal—Westinghouse "Visicode"		
Race Street	24	5.3
*Reading Terminal	6	5.0
Brown Street	7	4.4
16th Street Junction	10	1.9
"WS" Tower	7	0.6
System C—Wayne Junction to Lansdale and Hatboro—Westinghouse "Visicode"		
Newton Junction	4	0.9
Tabor Junction	3	1.6
Elkins Park	7	4.0
"DB" Tower	4	6.0
Glenside	5	6.7
Roslyn	4	8.7
*Hatboro	5	13.2
Oreland	6	8.4
*Ambler	20	11.7
Gwynedd Valley	5	14.8
*Lansdale	21	19.0
System D—Wayne Junction to West Trenton—Westinghouse "Visicode"		
*Jenkintown	32	5.8
Roelofs	7	23.1
*Yardley	24	25.2
System E—Wayne Junction to Neshaminy Falls—General Electric "Synchronous Selector"		
*Bethayres	20	9.7
*Neshaminy Falls	34	15.6
**System B—Wayne Junction to Chestnut Hill—Westinghouse "Visicode"		
Wister	4	1.0
Sedgwick	5	3.6
*Chestnut Hill	16	5.7
**System F—Wayne Junction to Norristown		
Manayunk	3	5.0
Conshohocken	3	11.0
Ivy Rock	2	12.4
*Norristown	21	14.7
Total—Present	255	
Total—Future	309	

* Transformer substation.
** Equipment under construction.

The supervisory control systems provide the dispatcher with the following operating features:

1. Control and indication on all circuit breakers and motor-operated trolley sectionalizing switches.
2. When an automatic operation occurs, an alarm bell is sounded, proper indication of the position of the unit is given, and a disagreement lamp indicates which unit has operated.
3. An alarm is sounded and an indication is given if any substation battery voltage reaches a predetermined low value; indication is also given when the battery voltage returns to normal.
4. An alarm is sounded and an indication is given if the temperature of any power transformer on the system reaches a predetermined high value; indication is also given when the temperature returns to a safe operating value.
5. All substation bus differential lockout relays are electrically reset by supervisory control.

Operating Experience

In the first 6 months of operation there have been several cases of low battery voltage indicated; in each case a maintenance man was sent to the station to make repairs and no serious trouble developed.

During the same period there was one bus differential relay operation which appeared to have been faulty. This occurred during the morning rush hour. The power dispatcher reset the lockout relays and reclosed the breakers, all of which re-

Full text of "Operating Experience With Supervisory Control on the Reading-Philadelphia Suburban Electrification" (No. 32M14) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

mained closed. No train delays were involved. On the other hand, had it been necessary to send a man to the station, serious train delays would have been caused at a most strategic hour.

The line wires are carried in a jute armored communication cable installed along the railroad right-of-way, which is used jointly for railroad telephone and telegraph circuits and supervisory control. To guard against line wire trouble a completely connected spare set of line wires has been provided for each system and the power dispatcher can transfer from one set to the other by merely pressing a button or throwing a switch on the control desk. There have been no cable failures; however, several cases of open line wires have occurred due to poor connections to terminals but there has been no time during which trouble was experienced on both sets of line wires simultaneously.

A thorough study was made to determine the effect of induction upon the operation of the supervisory control equipment, also of methods of draining the induced current. On the 2-wire "visicode" systems the drainage consists of a resistance connected between each line wire and ground and on the 4-wire "synchronous selector" system a resonant drain is employed, consisting of a condenser in series with a reactor connected between each line wire and ground. In both systems, vacuum type protector tubes which are self-recovering when the high voltage is reduced, protect the line wires from voltage in excess of 300 volts caused by a cross with a high voltage circuit, from lightning or from an exceedingly severe short circuit. Fuses and carbon type protector blocks used on the railroad telephone and telegraph lines are not used on the supervisory control line wires in order to eliminate the possibility of open circuits and grounds. Operating experience has indicated that the drainage employed is adequate and that there have been no failures caused by induction.

Installation, Testing, and Maintenance

Installation and testing of the supervisory control equipment offered no serious problems, the entire installation being carried out by the Reading Company's electrification forces. There were a few minor difficulties encountered during the testing period, such as trouble from blown fuses and necessity for readjusting relays which were altered during shipment. Tests consisting of load and short-circuit induction were conducted to determine the efficacy of the drainage equipment. Load induction was simulated by tying the trolley to the rail at the end of the line. The voltage then was raised until the desired current was circulating. Current up to 1,500 amperes was stub fed over 14 miles of trolley rail circuit, and no difficulties in the operation of the supervisory control equipment were experienced. Further, no trouble occurred when full-voltage short circuits were applied at the end of the line fed in the same manner. Following the induction test, power system tests were conducted throughout the entire electrification territory and whenever possible test setups were made by the power dispatcher with supervisory control and all indication of circuit breaker operations given by the supervisory control were checked. Any difficulties arising were immediately analyzed and corrected. The thoroughness of the tests applied prior to the starting of revenue service undoubtedly has helped to effect the creditable operation of the equipment.

At an early date it was realized that the maintenance of the supervisory control equipment would require a skilled man capable of tracing the circuits and adjusting telephone type relays. The railway company employed a man and gave him every opportunity to become thoroughly familiar with the equipment. He remained at the factory during its construction and inspection, following closely the installation and finally the testing. Since the entire system operation is dependent upon the operation of the supervisory control equipment, proper provision for the maintenance of this equipment warranted special consideration. Just after the starting of revenue service, a second man familiar with telephone type relays, was employed as a helper, since it was felt that one man should be available at all times in case of emergency.

The routine maintenance of the supervisory control equipment requires 50 per cent of the

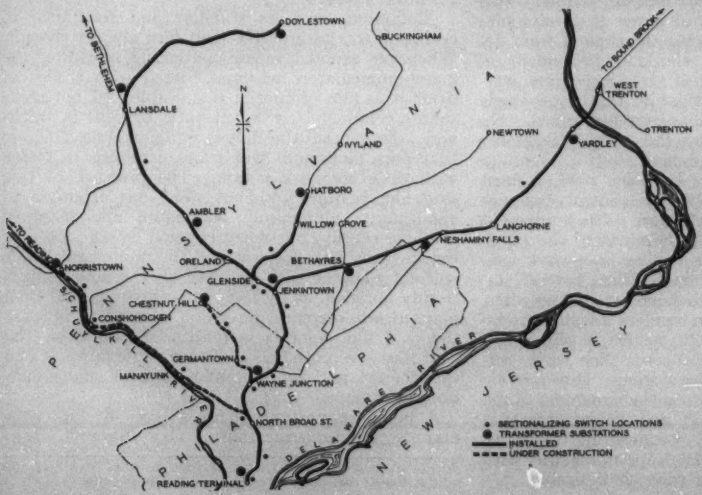

Fig. 1. The Reading-Philadelphia suburban electrification, to which supervisory control has been applied

time of 2 men, the remainder of their time being spent on general substation maintenance. The following supervisory inspection schedule is in effect:

1. Two-week Inspection:
   - Check of batteries
   - Check of charging equipment and charging rate
   - General inspection of relays
2. Three-month Inspection:
   - Detailed inspection of all equipment
   - Clean relay contacts
   - Adjust relay contacts
   - Check all moving parts
   - Calibrate voltage-indication relays

Once each week the power dispatcher operates every device including the opening and reclosing of each circuit breaker and motor-operated trolley sectionalizing-switch on the system. This procedure not only checks the supervisory control equipment but also checks the closing and tripping circuits together with the mechanisms of all devices. Close contact is maintained between the operating force and the engineering department. The power dispatcher's daily reports include supervisory control failures, together with their cause if known. In addition, a monthly report of supervisory control failures covering the details of each failure is compiled by the operating department. This report is analyzed, failures are classified, and a curve of monthly failures is plotted.

Results

The first 6 months of operation represents 126 station-months; 35,000 operations were performed and 35 failures occurred, or 1 failure per 1,000 operations. Of the 35 failures, 11 were due to interposing relays, 6 were caused by blown fuses, and 18 by failure of supervisory control twist keys and relays.

In many cases the constant visual indication given by the system diagram on the control board has provided the power dispatcher with the necessary information enabling him to think logically, clearly, and rapidly at the time of trouble. This resulted in the restoration of power in a minimum amount of time, thus reducing the time of train delays. The advantage of eliminating divided responsibility and possibility of error in communicating orders is borne out in the fact that not a single faulty switching operation has been performed. No operations not initiated by the power dispatcher were performed by the equipment.

Although its performance has been good, it must be recognized that supervisory control has not reached a final stage of perfection. The equipment can be improved by further eliminating the possibility of failures. Systems where line wires loop through stations are undesirable when several stations are operated over the same set of line wires, since a fault in one station renders all stations inoperative. With the present system in which stations are operated in parallel across line wires, certain troubles tie up the entire system. However, by disconnecting the faulty station the remainder of the system can be operated. It may be possible that a scheme for automatically disconnecting the faulty station can be developed. High speed, together with a minimum number of line wires, is desirable.

Oxid Coatings on Aluminum

Although possessing great affinity for oxygen, aluminum has the unique property of being able to protect itself from corrosion by forming on its surface a hard, thin, and almost invisible oxid coating. Characteristics of this film and some of its many uses are described in this article.

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INTEREST in oxid coatings on aluminum began with the discovery of the metal about 100 years ago, as the chemical attraction of aluminum for oxygen is one of the most important characteristics of the metal. At various times in the history of aluminum, attention has been focused upon the oxid film, from the scientific standpoint or from the commercial standpoint. To the scientist the electrical characteristics of the oxid film have been of great theoretical interest and for many years have been the subject of experimental study and speculation. Important commercial uses of the film in various electrical devices has followed the scientific studies.

Aluminum owes its stability and resistance to corrosion to the invisible oxid film always present. Whenever exposed to air containing moisture, the metal immediately becomes coated with a film of oxid; this film ordinarily is invisible and not more than a relatively few wavelengths of light in thickness. In general the film is quite impermeable, so that pure aluminum will stand exposure to water with little corrosive action. The presence of this oxid film is quite apparent when one attempts to amalgamate aluminum. Aluminum and mercury combine readily, but when covered by an oxid film the mercury will not wet the aluminum and hence will not combine with it. Even if the aluminum is freshly abraded, as by filing or scratching, and then plunged into mercury, no action takes place because the oxid film reforms instantly. If, however, the oxid film is removed by abrasion while immersed in the mercury and out of contact with air, amalgamation takes place.

A highly important characteristic of this oxid film is its impermeability. Oxid formed from

Full text of a paper "Oxid Coatings on Aluminum" (No. 32-78) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20-24, 1932.

aluminum occupies a greater volume than the aluminum from which it is formed; apparently this results in a compact and non-porous film with great protective properties. Even on continued heating at high temperatures, the film shows relatively little increase in thickness. Although impermeable to gases, the oxid film as naturally formed has a negligible electrical insulating effect and offers little resistance to the passage of current, even at very low voltages. This is fortunate, and permits the manufacture, for example, of variable air condensers with aluminum plates held in their mountings by mechanical pressure, with no increase in resistance over similar condensers of other metals in which the plates are soldered to the supporting pillars.

The asymmetric character of the film "artificially" produced, when aluminum is made the anode in various electrolytes, has been of great scientific commercial interest. Since the rise of the radio industry, extensive use of film-coated aluminum has been made in the electrolytic rectifier and, more recently, in the electrolytic condenser. High capacity in small volume and at low cost has proved a great stimulus to the development of the electrolytic condenser. Originally marketed in the form of a cell containing electrodes immersed in a substantial volume of electrolyte, the trend for small condensers, at last, is now largely toward the so-called "dry" form, in which a limited volume of electrolyte is held absorbed in a paste kept in contact with the electrodes. In all of these devices, however, the oxid film—at least the active part—is quite thin.

Thicker Coatings Now Being Used

Extensive use of oxid coatings having thicknesses comparable with those of paint films is a relatively recent development. If aluminum is made the anode in boric acid, the potential drop at the anode may be increased to a value of about 400 to 600 volts with very little current passing; the film, once formed, is thin and shows little tendency to decrease or increase in thickness. If, however, an electrolyte of different chemical characteristics is chosen, as, for example, a dilute solution of sulphuric acid or oxalic acid, a different behavior is noted. Within limits, the oxid film may be built up to a substantial thickness, since the potential may not rise above from 10 to 50 volts, and current continues to pass until thick films have been formed, say, 0.001 in. or over. Films formed in this latter way, when removed from the electrolyte and dried, have desirable mechanical, chemical, and electrical properties. The film in respect to hardness partakes of the characteristics of corundum, which is a hard, crystalline oxid, Al_2O_3. Because of this hardness, it possesses wear and abrasion-resistant qualities that can be made use of commercially.

Dielectric strength of these dry films can be made sufficiently high so that the films can be used for electrical insulation on wire, sheet, and foil, to be used as conductors and in condensers, respectively. In a chemical way, the films can be made with or without high adsorptive properties, so that they can be colored by absorption of dyes or mineral pigments; this opens up a new and extensive field for obtaining decorative effects. These thick oxid films on aluminum can be obtained not only by electrolytic treatment, but also by direct chemical action of various solutions on aluminum. Properties of these thick films are discussed in succeeding paragraphs.

In the formation of oxid coatings on aluminum by electrolysis oxid is formed at the interface between the aluminum and any oxid coat already existing. It might be thought, therefore, that the oxid coat could be increased to any thickness as long as the coating remains sufficiently permeable to permit the passage of current. Another limiting factor, however, is the solvent action of the electrolyte upon the film. Most electrolytes that are useful for producing thick coatings have an appreciable solvent capacity for aluminum oxid, usually increasing with rise in temperature; thus the anodic coating process becomes a race between the oxidizing action of the current and the solvent action of the electrolyte. The oxid coating also may have its characteristics changed by specific chemical reactions with the electrolyte.

An interesting experiment with an electrolyte of low solvent action gave a series of 8 coatings which by direct measurement of microscopic sections were found to have an average thickness of 0.00038 in. Direct measurement showed also that the aluminum sheet used in the experiment had increased in thickness by 0.0002 in. as a result of oxidation on both sides, so that the increase in thickness attributable to a single oxid film is 0.0001 in. The aluminum, therefore, in forming the oxid increased in volume by about 35 per cent. This is a difficult measurement to make with precision, the values obtained ranging from about 15 to 60 per cent. When, however, electrolysis was carried out with a solution in which aluminum oxid was highly soluble, the sheet frequently showed a total decrease in thickness many times the thickness of the oxid coating, even though the coating itself was of substantial thickness.

Coatings described in the previous paragraph were subjected to X-ray examination by the powder method and were found to be amorphous—at least no evidence of crystallinity was observed. Water in the coating there probably is held by adsorption, and not as one of the crystalline hydrates of aluminum. However, by a special after-treatment the oxid can be converted, at least in part, into crystalline aluminum mono-hydrate; this change is accomplished by a marked decrease in the permeability of the film and an increase in its dielectric and protective properties.

Oxid Film an Insulator

From the standpoint of the electrical engineer, the possibility of using an oxid coat as insulation on aluminum conductors is a matter of considerable interest. The idea, of course, is quite old and has been applied commercially to some extent, particularly abroad. The present advanced technique and

knowledge of oxid coatings now available has created a new interest in these coatings. In certain types of electrical machinery, the use of aluminum conductors would be advantageous from the standpoint of weight reduction. Another advantage of the oxid-coat insulation is that it is non-combustible and will withstand fairly high temperatures without deterioration. There is even a possibility of its use as a dielectric in dry condensers.

Breakdown voltage of oxid films is roughly proportional to the thickness of the film. The breakdown characteristics, however, are dependent also upon the specific physical and chemical characteristics of the film. In Fig. 1 is shown a series of observations on the breakdown voltage of oxid films on commercially pure aluminum, plotted as a function of the thickness of the oxid film. This particular film was made by anodic coating of aluminum in a 15 per cent solution of sulfuric acid at a temperature of 75 deg. fahr. To produce an oxid film 1 mil thick required a period of about 1 hr, under prevailing operating conditions. By special after-treatment, without introducing any organic material into the film such as that referred to in a previous paragraph, the breakdown voltage of the film may be increased as much as 50 per cent or more. The oxid coatings also can be produced in absorbent form, and in this condition can be impregnated with oils, waxes, or enamels; such treatment imparts to the coatings a substantial increase in insulating value.

Oxid Coating Harder Than Base Metal

That the oxid coat is much harder than the base metal is at once obvious if an attempt is made to scratch the surface. Some quantitative data have been obtained by subjecting films of various thicknesses to an abrasion test consisting of abrading the surface with an aloxite wheel under light pressure. The abrasion resistance is measured in terms of the number of revolutions which the specimen makes against the abrasive wheel. These data are given in the Table I.

According to Table I, the abrasion resistance of an oxid coating increases rapidly as the thickness of the film increases beyond about 0.3 to 0.4 mil. For comparison with these figures, reference may be made to the abrasion resistance of enamel and varnish coats such as applied in finishing metal furniture and office equipment. A typical finish of this type, consisting of primer, 2 ground coats, graining coat, and 3 coats of finishing varnish, having a total thickness of 3 mils, showed an abrasion resistance of 306 revolutions; a somewhat different finish of the same thickness showed an abrasion resistance of 1,095 revolutions. For equivalent thicknesses, therefore, the oxid coat is substantially harder than the baked enamel just mentioned.

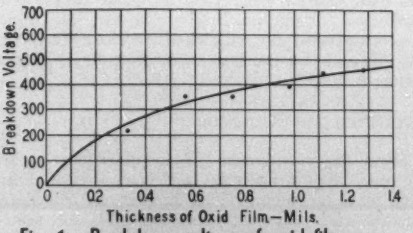

Fig. 1. Breakdown voltage of oxid films on commercially pure aluminum

Table I—Abrasion Resistance of Aluminum Oxid Coatings

Thickness of Coating, Inches	Abrasion Resistance, Revolutions Against Aloxite Wheel
0.00011	15
0.00019	95
0.00031	268
0.00037	365
0.00074	2,563
0.00148	7,061

Oxid films not over 0.1 to 0.3 mil thick on thin sheet can be formed readily into bottle caps and similar articles. These films of course crack on bending, but the cracks are so minute as to be generally undetectable except under the microscope; adhesion of the film to the metal is so firm that no flaking occurs even when these cracks are present. These minute cracks appear to have very little, if any, effect on the insulating value of the coating. In addition, tests made so far indicate that the oxid coat does not affect unfavorably the fatigue strength of the base metal.

As has been mentioned already, oxid coatings may be applied to aluminum by chemical dip methods without the use of electric current. Such coatings, while unusually relatively thin, nevertheless have been used commercially, both in the United States and abroad, for their insulating value. Because of their characteristics, such coatings are of use only when subjected to low voltages; therefore their greatest use is in motor field coils and similar applications where the voltage drop between the conductors is low.

Certain types of oxid coatings are decidedly absorbent and can be colored readily with dyes and mineral pigments. These methods of coloring the oxid coatings present interesting possibilities in the electrical industry. Wires may be colored, for example, to indicate polarity of direct current; where several wires are in a single conduit, the colors may be used to identify the various circuits. For rapid heat dissipation, busbars and other conductors may be colored black. The bottoms of aluminum utensils for use on electric stoves may be colored black for better heat absorption. Commercialization of plain and colored "alumilite" finishes in the electrical industry already is under way; oxid-coated and colored nameplates are finding increasing use; a tremendous number of aluminum flashlight cases in attractive colors has been manufactured. Furthermore, practically the entire electric refrigerator industry has turned to the use of aluminum refrigerator trays and grids with plain anodic coating. It is quite evident that these finishes will be of increasing value to the electrical industry in the future.

A Bridge Method of Testing Welds

A new non-destructive method of testing welds by an electrical means has been developed which can be applied to welds made in the field as well as to those made in the shop. A reliability of 8 out of 9 welds tested, or 89 per cent, already has been obtained and gives good promise for the future. The method may be applied also to the finding of flaws in other homogeneous objects of magnetic materials.

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SINCE the advent of welding there has been an ever-growing demand for a simple and satisfactory non-destructive test for completed welds. Several schemes have been devised and used successfully in the experimental laboratory and in the shop. Among these are (1) the stethoscope method, (2) the X-ray method, and (3) various electrical and magnetic methods.

Of these systems the X-ray method and one of the electrical methods have been successfully used in the routine production testing of welded boilers at the Babcock and Wilcox boiler works. Both of these systems, however, are chiefly limited to shop use, and are not readily adapted to the conditions of field work.

It has been suggested that a satisfactory non-destructive testing device should possess the following 3 characteristics: first, the device must be portable; second, it must give instrumental indication of flaws; and third, it must give instrumental indication of the relative strength of the weld as compared with the stock from which it was made. Thus the ultimate goal to be achieved was set, and constantly kept in mind as the work progressed. After due consideration, it was believed that an a-c bridge with a visual balance indicator offered the greatest possibilities.

Theory of the Test

It is well known that the inductance and the effective resistance of a coil which has an iron core depend upon the magnetic circuit. Therefore if an air-gap is introduced into that magnetic circuit, then the inductance and effective resistance have new values. This is the basis upon which the bridge method of testing welds operates.

The most satisfactory method of measuring the inductance and effective resistance of a coil is by some form of impedance bridge. In the preliminary tests, an exploring device similar to that shown in Fig. 1 was constructed and connected to an impedance bridge which was available. This particular bridge did not give good results. Investigation of the theory of its operation showed that for measuring inductance it was a comparison bridge and the least accurate of the general types of the impedance bridge. In the comparison bridge the calibrated standard is the same as the unknown; that is, a standard inductance is used for measuring an unknown inductance and a standard condenser for measuring an unknown condenser. This type of bridge is difficult to balance with very great accuracy. The resonance bridge gives a much more sharply defined balance point and is therefore much more accurate. It makes use of a standard condenser to measure an unknown inductance and a standard inductance to measure an unknown condenser. A series resonance bridge therefore was constructed for making the measurements of the change in the inductance and the effective resistance of the exploring device.

Description of Apparatus

The complete equipment which finally was developed is shown in Fig. 3, the schematic diagram being shown in Fig. 4. The equipment consists of 4 major parts:

1. The oscillator which supplies the alternating current for the operation of the bridge.
2. The bridge by which the measurements are made.
3. The exploring device for examining the weld.
4. The balance indicator which shows the condition of the weld.

The oscillator consists of a single tube with inductive coupling between the plate and grid, and with a transformer in the plate circuit for obtaining the output. The variable condenser shown connected across the grid coil controls the frequency. The low pass filter section was used to eliminate the harmonics from the oscillator output.

In the impedance bridge R_1 and R_2 are the ratio arms of exactly equal non-inductive resistors. The variable resistance R_3 balances the effective resistance

Fig. 1. (Left) Exploring device across a weld
Fig. 2. (Right) Balance indicator used in laboratory

Essentially full text of "A Bridge Method of Testing Welds," presented before an A.I.E.E. joint meeting of the Portland Section and Oregon State College Student Branch, at Corvallis, Ore., May 23, 1931. This paper, written while the author was a senior in electrical engineering at Oregon State College, was awarded the Institute's 1931 national prize for Branch paper.

Fig. 3. Complete laboratory equipment used in test

of the exploring device. The condenser C balances out the inductance of the exploring device. It consists of several fixed condensers in parallel with the standard variable air condenser.

The exploring device consists of 2 coils each of many turns of fine wire wound on the 2 legs of a U-shaped magnetic circuit, the magnetic circuit being closed by the weld under test as shown in Fig. 1.

The balance indicator is the most complicated of the 4 parts which make up the equipment. It is a very sensitive vacuum-tube voltmeter. This high sensitivity is obtained by means of the amplifier which is composed of the 3 transformers and the first 2 tubes shown in Fig. 3. The first of these is a $UX240$ with an amplification factor of 30; and the second, a $UX201$-A with an amplification factor of 8. This amplifier has a voltage gain of approximately 20,000 to 1. The detector tube is a $UX201$-A with the milliammeter shown in Fig. 2 in the plate circuit and shunted by a large condenser, and the plate battery to bypass any unrectified alternating current. The milliammeter was provided with a shunt S to increase its range to 10 times full scale value during the preliminary balancing and when first energizing the tube filaments. Also a high variable resistance in series with a single dry cell was connected as shown in Fig. 4 so that it sent a current through the milliammeter in the reverse direction to that of the tube. By this means it was possible to make the voltmeter read zero when there was no voltage impressed across its terminals, and the steady plate current reading could be removed from the instrument.

A vacuum-tube voltmeter was used for 2 reasons: first, it required almost no power from the bridge for its operation as would a thermocouple or ordinary voltmeter; and second, it was much more sensitive and had a uniform scale. The minimum sensitivity was $1^1/_4$ mv. Each succeeding millivolt up to about 4, which was as high as the calibration was carried, caused an increase in the deflection of about 0.10 ma. At these low values the calibration curve was not always a straight line but followed the tube characteristic.

Method of Making the Tests

Rated current was maintained in the tube filaments at all times by the aid of the filament ammeter shown in front of the right hand storage battery in Fig. 3. The oscillator filament ammeter does not show plainly but was very important in keeping the output at a constant level. The reverse current then was adjusted so that with the voltmeter terminals open and the shunt removed the milliammeter had a reading of 0.10 which hereafter will be used arbitrarily as 1.0, thus increasing each reading to a whole number for each 0.1 ma of current.

The shunt switch then was closed again to protect the milliammeter, and the output of the bridge was connected to the voltmeter by closing the switch shown just behind the first tube in Fig. 3. Then the exploring device was placed on the stock near the weld, but not across it, and the bridge brought into balance by adjusting the variable air condenser and the variable resistor shown beside it. A balance was shown by a minimum reading of the voltmeter. When the reading was as near zero as possible the shunt was removed by opening the switch (the handle of which shows from behind the milliammeter) thus greatly increasing the sensitivity. The final balance then was obtained and the reading arbitrarily made exactly 1.0 by means of the reverse current control resistor which is shown beside the milliammeter in Fig. 3.

The exploring device then was slid along the plate to see that the balance was correct and that there was no very marked change in the indicator reading. The shunting switch was then closed and the exploring device placed over the weld as in Fig. 1. If the deflection indicated that the reading would not be off scale the shunting switch was opened and the exploring device moved along the weld, while the operator observed the indicator reading.

If the weld was as good as the stock from which it was made, then the bridge balance would be undisturbed and the reading was the same as it had been over the stock, or 1.0; but if there was a blow hole or burned place in the weld this would unbalance the bridge by changing the inductance and effective resistance of the exploring device. This flaw was indicated by an increase in the reading to 2.1 or some other value as the exploring device passed over the flaw. Also a note was made of the percentage of the width of the weld for which this high reading existed; this together with the lowest reading over the weld formed the basis for computing the efficiency of the weld. To take an actual example; the reading with the exploring device over the stock was 1.0, the minimum reading over the weld was 1.7, and the maximum reading was 2.0 for 60 per cent of the

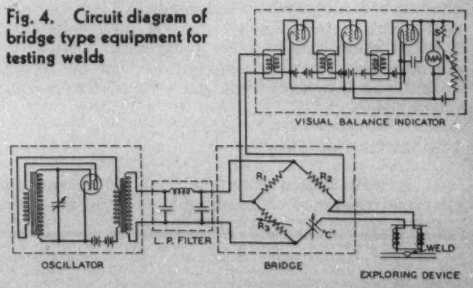


Fig. 4. Circuit diagram of bridge type equipment for testing welds

width of the weld. The efficiency was computed as the reading over the stock divided by the reading over the weld, or for the maximum efficiency 1.0 divided by 1.7 or 59 per cent, and for the minimum efficiency 1.0 divided by 2.0 or 50 per cent. But this lower efficiency was present for 60 per cent of the weld; therefore the true efficiency was 60 per cent of the way from 59 per cent toward 50 per cent, or 54 per cent for the weighted efficiency of the weld.

Before making the tests the loose scale and the splatter were removed by rubbing lightly with a piece of emery cloth. This was done because these small globules prevented smoothly sliding the exploring device along and gave false indications when they touched the pole pieces.

Results Obtained

Through the months of January and February, 1931, about 18 welds made by students were available each week for testing. These were tested by the bridge method and their efficiencies calculated as explained. These welds then were tested in tension to obtain an actual breaking load for each one. During nearly every week some one of the specimens failed in the stock instead of in the weld, and the load at which that failure occurred was used as the strength of the stock for that week in computing the actual efficiencies. These actual efficiencies were computed by dividing the load at which the weld failed by the load at which the stock failed, because all of the welds were made from $^1/_4$ x 2 in. stock and except for slight irregularities in the stock due to rolling, had the same area.

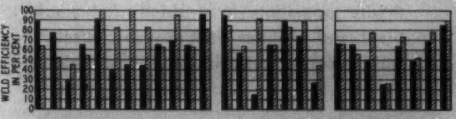
The results of tests upon an early group of specimens from which the scale was not removed are shown in Fig. 5. At that time there were no copper legs on the exploring device, heavy paper being laid on the stock to give a smooth surface. In the next series of tests, the results of which are shown in Fig. 6, the scale and globules were removed from the welds with emery cloth, but paper was still used on which to slide the exploring device.

After the exploring device was equipped with copper legs as shown in Fig. 1, another group of welds was tested and retested until results could be duplicated readily to within 1 or 2 per cent. These welds were then tested in tension; the results are shown in Fig. 7.

Discussion of Results

Even the first group of welds tested showed a tendency for the efficiency calculated from the bridge readings to follow the efficiencies found in the actual destructive tests. After the bridge testing technique was improved the results increased in reliability. For the group of Fig. 5 the reliability was 33 per cent; for the group of Fig. 6 it increased to 57 per cent; and for the group tested after the copper legs had been added and the paper eliminated, Fig. 7 shows that the reliability jumped to 89 per cent, which is most gratifying. This shows rather conclusively that the basic theory is sound and that the errors which occurred were due to imperfect apparatus and not to theory; for as the quality of the apparatus increased, so did the reliability of the tests.

In every change in the apparatus the 3 desirable characteristics were kept in mind and are fully met by the method. As to the first, portability, while the laboratory outfit used for the present series of tests is not exactly portable, nevertheless, there is no reason why both the space required and the weight cannot be very greatly reduced. The matter of small size can be accomplished readily by the proper choice of equipment. All of the parts except the batteries and the exploring device could be assembled in a box about one-half the size of the standard condenser shown at the left in Fig. 3. The matter of battery weight also can be controlled by using the



Figs. 5, 6, and 7. Results of early tests (left) before scale was removed from specimen; results obtained (middle) after removing scale; and later tests (right) after copper legs were used on exploring device and without paper laid on stock

Efficiencies as obtained by the bridge method are shown as solid bars, and actual efficiencies from tension tests as the shaded bars

very small sized light-weight batteries. The bridge method meets the second requirement; namely, that the indications be visual. It also meets the third requirement that the readings show a direct comparison with the stock.

The exploring device shown in Fig. 1 was developed for testing single *V* butt welds, but can be modified for use in testing other kinds of welds. One design for reaching into corners is to bend the crossarm connecting the 2 pole pieces until the pole pieces form a right angle and one of them rides on each side of the angle. Another is to still keep the *U*-shape but to make the ends of the pole piece hemispherical in shape, so that when they are placed in the angle they still make as good contact as they did on the flat plate. An offset in the connecting crossarm which would allow one pole piece to operate at a lower level than the other would make it possible to test fillet welds when one piece of stock was placed on top of the other to form a lap weld.

Also it may be desirable to replace the long copper skid with 2 wheels and the short one with 1 wheel, all of non-magnetic material. It would still be necessary to remove the splatter since if rough spots come in contact with the pole piece the balance is disturbed.

The results obtained by this method are most promising; the reliability was increased with each improvement until with a slightly more stable oscillator and a suitable period for the tubes to become stable the results should be very satisfactory. This method does not involve the use of large currents and can be made self-contained and independent of outside power supply.

Carrier Application to a Telegraph Plant

Carrier communication has been found to provide an economical means of conveying not only telephonic but also telegraphic information. This article describes the transmission and equipment features of a 10-channel system recently developed for 4-wire operation in a strictly telegraph plant, and includes performance characteristics showing capabilities of the system.

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USE OF CARRIER SYSTEMS has been rapidly increasing for the last 10 or more years in the wire communication networks of this and foreign countries. To a large extent, this is due to the economies realized from the use of this means of conveying telegraphic or telephonic information, especially over relatively long distances. A gradual increase in copper costs over the early part of this period no doubt was directly responsible for the increased application of carrier systems in the communication field. However, it is noteworthy that even at present low copper costs the use of carrier still maintains a liberal margin of economy. This is due mainly to the material advancement in the carrier art which has been manifest in circuit refinements, improved performance, and simplification of equipment design, as well as improvement in the technique of coordination with the same or other types of communication facilities.

The majority of applications has been confined, primarily, to telephone plants or communication networks, employing largely metallic circuits. This is natural to expect since the design and construction of the wire and cable plant for telephone operation possess the essential transmission requirements for satisfactory carrier operation. A quite different and, in many respects, more difficult problem is encountered in introducing carrier into a strictly telegraph plant because in general the growth of present-day telegraph plants has been restricted by the wide use of d-c telegraph circuits that could

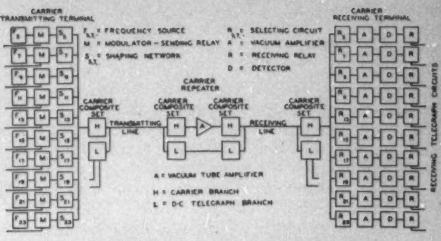

Fig. 1. Schematic diagram of 10-channel carrier telegraph system for 4-wire operation
Frequency indicated in hundreds of cycles per second

be operated fairly successfully on a ground return basis. Consequently, it has not been the general practise of the telegraph companies to construct and maintain their open wire and cable circuits in a way that would provide balanced metallic circuits suitable for carrier operation. Furthermore, the operating energy levels of the various circuits on the same lead are not restricted by the presence of other types of communication circuits occupying a frequency transmission range other than that required for d-c telegraph signals. In general, this outlines the fundamental difference in the transmission problem involved in applying carrier to a telegraph plant.

Other equally important factors also enter into the problem, the foremost of which is the fundamental difference in the traffic requirements imposed on the telegraph plant by the particular class of communication business handled. Telegraph service by its very nature demands great flexibility; but even greater flexibility is needed when carrier is applied. Hence it has been found desirable to provide considerable flexibility in the design of the carrier equipment itself.

General System Requirements

Technical development features arising from the specific problem of designing and developing a carrier telegraph system primarily for use in the extensive domestic telegraph plant of the Postal Telegraph-Cable Company are presented in this article. This includes the performance results obtained, and a detailed description of the final standardized system.

At the time this development was undertaken, a careful study first was made of all known types of carrier telegraph systems and accepted practises employed in both the United States and in foreign countries. From this study, together with a full appreciation of the problems peculiar to adapting carrier to a telegraph plant, it was possible to set up basic requirements to be met by a carrier system capable of delivering a satisfactory quality of signal and standard of service. As a result of this investigation, the following general requirements arbitrarily were set up as an ideal to be approached:

1. Each channel of the system should be capable of handling a quality of signal commercially suitable for existing or contemplated printer operation.

Based upon "Carrier Application to a Telegraph Plant" presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932. *Pamphlet copies not available.*

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2. Transmission characteristics for all channels in any one particular system should be uniform, to permit unlimited interchangeability of telegraph printer facilities.

3. Transmission stability of the system should not impose any additional limitations on the operating requirements for any particular telegraph facilities used over the carrier system.

4. A unit equipment design should be employed which would embody sufficient flexibility to fulfil economically the demands of a diversified traffic growth.

5. The system should coordinate to the fullest extent with the inside and outside plants for present or future telegraph facilities of the same or different type.

Naturally, additional requirements of a more specific nature were prescribed for the initial design. These have been omitted since they do not materially relate to the subject matter of this article.

Technical Features of Design

Having chosen suitable relays with satisfactory operating characteristics, particularly with regard to efficiency, sensitivity, and freedom from chatter and bounce, the first consideration was that of frequency band width and frequency allocation of the carriers. While the required signaling band width was well defined for the existing printer facilities, it was logical to make provision for band widths expected from contemplated future telegraph facilities under development. This led to a design of selecting circuit which could be adjusted readily to any desired band width. Details of these structures will be treated more at length later.

In reviewing all previously published information at hand, it was apparent that some variance among authorities existed in regard to the proper relation that should be sustained between signaling speed and minimum band width necessary to satisfy fundamental transmission requirements. A proportionality factor of 1.5 times twice the fundamental signaling frequency was used in determining the appropriate band width. This is in substantial agreement with prevailing practises, which specify equivalent values ranging from 1.2 to 2.0 times twice the dot frequency. Other practical considerations resulted in prescribing frequency bands wider than the theoretical value indicated, in order to provide operating margins that would insure continuity of service.

Directly related to the matter of band width is the problem of allocating the carrier frequencies. Obviously, the degree of selectivity which could be obtained economically was the essential limitation in fixing the positions of the carrier frequencies in the assigned frequency spectrum. As this system was to be the initial carrier system in an existing telegraph plant made up almost exclusively of d-c telegraph facilities occupying the lowest end of the frequency spectrum, it was natural to assign for this carrier system a frequency range immediately above, in the voice range.

It is well recognized of course that practical considerations dictate how efficiently the frequency range should be utilized. For example, the frequency space may be divided for suitable operation of start-stop printers. This would require a band width of approximately 75 cycles and would permit relatively close spacing of the carrier frequencies. For a given frequency range a given number of channels could be allocated, each of which would have an operating limit of 65 words per minute. By slightly increasing the band width to 100 cycles, it would be possible to divide this same given frequency range into a fewer number of channels, each capable of transmitting 2 channel multiplex signals with an operating capacity of 120 words per min. per carrier channel. This line of reasoning may be continued on to include 3- or 4-channel multiplex operation. While it would be possible to determine from such an analysis the best combination, from a standpoint of obtaining the greatest message capacity, in a given frequency range, it would not necessarily make the most practical use of the frequency space. The band widths finally chosen were based upon these considerations and also upon the smoothness with which carrier telegraph systems could be introduced into the telegraph plant. It appeared advisable to restrict the lowest carrier frequency to 500 cycles in order to allow ample frequency space for retaining on the same wires existing high speed d-c telegraph circuits.

Fundamental operation of all carrier telegraph systems is essentially the same. Before describing this system in detail it will be well to enumerate the principal components that go to make up any carrier telegraph system. A system comprises several individual channels, uniformly alike in make-up and normally comprised of the following essential parts:

1. A transmitting terminal consisting of frequency sources, modulators, and shaping networks.

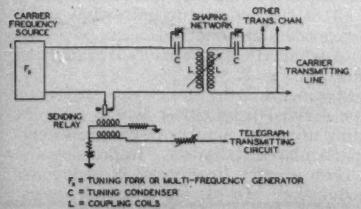

Fig. 2. Schematic diagram of transmitting channel

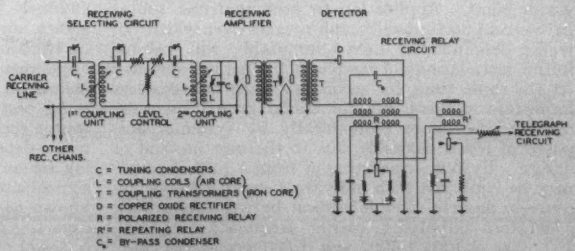

Fig. 3. Schematic diagram of receiving channel

Fig. 4. Assembly of shaping network unit

Fig. 5. Oscillogram showing over-all telegraph transmission over a typical channel

A—Signal repeated by receiving relay to receiving equipment
B—Modulated carrier current shaped for transmission
C—Originating telegraph signal received from transmitting telegraph equipment

2. Repeaters consisting of 2 separate one-way amplifiers each common to all of the channels.

3. A receiving terminal consisting of selecting circuits, amplifiers, detectors, and receiving relays.

Each tuning fork generator operates on 100 to 200 milliamperes of current from a 6-volt battery supply in common with all other generators. From each generator 60 milliwatts of power into a 600-ohm load circuit is available, if transmitting level conditions require utilizing the maximum generator outputs. Generated power output available from the multi-frequency generator at each channel frequency is 375 milliwatts into a 600-ohm load circuit. Speed control equipment associated with the unit insures a constancy of generated frequencies to within $^1/_4$ of a per cent, for normal line voltage variations.

The purpose and functions of each of these parts already have been ably described in previous publications; therefore, the remainder of this article will be confined to a more detailed description of the apparatus developed for this particular system.

The system as a whole has been designed initially for 4-wire operation over composited open wire telegraph lines. Fig. 1 shows schematically the system layout of half of the equipment for 10 2-way carrier channels; the other half of the system obviously is identical to that part shown except that it transmits in the opposite direction.

One of the unique features incorporated in the system design was the degree of flexibility provided for satisfying the diversified use of carrier telegraph circuits, and which proved essential for meeting economically the requirements of a domestic telegraph plant. Application to existing trunk routes between important telegraph centers over which the traffic demands are heavy invariably will call for initial installations of complete 10-channel systems. At the same time, for secondary leads between less important centers, normal traffic growth may be provided for more economically by systems composed of fewer channels, due to the unit method of design. Systems consisting of from 1 to 6 channels may be equipped with individual channel frequency sources, namely, double carbon button tuning fork generators supplying carrier frequencies of 500, 700, 900, 1,100, 1,300, and 1,500 cycles per sec.; for systems requiring more than 6 channels a carrier frequency source from a multi-frequency generator supplying the following frequencies is provided: 500, 700, 900, 1,100, 1,300, 1,500, 1,700, 1,900, 2,100, and 2,300 cycles per sec.

It is readily apparent that a system design such as this is capable of being adapted to the usual communication network in an economical manner. The providing of additional channels for operating systems of 1, 2, 3, or more channels may be carried out expeditiously, without affecting the channels already in service. When a system has grown to 6 channels and additional channels are required, the individual tuning fork generators are replaced by a multi-frequency generator.

Superposition of the carrier system upon the telegraph lines is accomplished by compositing. Carrier composite sets are provided at the terminals and repeater points for restricting the carrier and d-c telegraph frequencies to their respective paths. The low frequency portion of the composite set requires a rather exacting design, as the d-c telegraph facilities operate at high speeds over the circuits employing ground return.

Telegraph line wires, which normally are untransposed for d-c operation, must be transposed to provide a suitable metallic circuit relatively free from noise or external interference for a carrier telegraph system. Loading of conductors in entrance and intermediate cables is required also, if full advantage of efficient transmission is to be realized.

Transmitting Terminal

In describing the transmitting and receiving channels, a description of an individual channel will suffice since all of the important units that make up the complete system are identical except for initial adjustment. A schematic diagram of a transmitting channel is shown in Fig. 2.

As previously mentioned, the carrier frequency source may be derived from either 1 or 2 different units, depending upon the number of channels making up any particular installation. Impressing the signals upon these carrier frequencies is commonly known as modulation. In carrier telegraph operation, this process may be carried out by interrupting a steady carrier frequency source in accordance with the actual signaling frequencies of the originating

telegraph signals. However, in the circuit arrangements of this system, superimposing telegraph signals on the carrier by open-circuiting between the carrier generator and the shaping network, what might be termed series modulation, has proved the most satisfactory. The method is evident from the circuit shown in Fig. 2.

It has been shown very clearly by mathematical analysis, and substantiated in practise, that a relatively small portion of the side frequencies present in the telegraph signal need be transmitted over a carrier circuit. (See "Certain Factors Affecting Telegraph Speed," H. Nyquist, A.I.E.E. Jl. v. 43, p. 124; "Voice Frequency Telegraphs," W. Cruickshank, *Journal* of the I.E.E., July 1929, v. 67, No. 391, p. 813; and "The Building-Up Processes in Wave Filters," K. Kupfmuller, *Elec. Na. Tech.*, 1924, v. 1, p. 112.) The degree to which the side frequencies may be limited is dependent entirely upon the signaling speed and the signal quality that will insure satisfactory performance of the particular type of telegraph equipment used in conjunction with the carrier system.

One of the outstanding features worthy of note in the design of this system is the application of the simplest known type of selecting circuit. The familiar coupled tuned circuit upon which the early wireless art depended for discrimination will be recognized in the shaping networks and receiving selecting circuits which form the essential parts of this carrier system development. The unique solution of the coupled tuned circuit problem by one of the authors, L. A. Kelley, has made possible a simple and convenient method for designing selecting circuits to meet any requirements for which they may be adapted. A detailed explanation of the method is presented in the article immediately following this one.

Treatment of coupled tuned circuits by this method offers a distinct advantage over existing technique for handling selecting circuit design, inasmuch as it is possible to determine the operating characteristics which a given selecting circuit will possess when connected into the working circuit. The importance of equipping carrier systems with selecting circuits uniform in structure and performance cannot be overemphasized. At the same time, if full economic advantage is to be realized from carrier operation, it is equally important that the manufacturing costs to produce the selecting equipment should be consistent with those for the other related equipment.

As may be noted under the discussion regarding performance, it has been possible to develop for this system relatively inexpensive shaping networks and receiving selecting circuits (patent applied for) that meet especially well all transmission requirements imposed. This is accomplished primarily by designing the selecting units for the entire system so that only one type of inductance coil is used throughout; obviously this greatly simplifies the manufacturing problem for selecting circuit equipment from the standpoint of electrical and mechanical dimensions. Advantage is taken of the desirable properties of the air core inductance coil for eliminating the possibility of modulation effects from the selecting circuits. A double tuned circuit is embodied in the shaping networks used at the transmitting terminals. Mounting arrangements for the circuit elements have been worked out in a convenient assembly, as shown in Fig. 4. As may be noted one inductance element is movable with respect to the other fixed inductance element; a calibrated scale is provided in order that any desired degree of coupling may be easily obtained. The major portion of each capacitive element is composed of fixed units, with the remainder made up of small adjustable units permitting closer tuning adjustment after the entire unit has been assembled.

Receiving Terminal

Adequate selectivity for separating out the various modulated carrier frequencies at the receiving terminal is obtained from triple tuned circuits embodying the same principles of design and equipment assembly as the transmitting shaping networks. A level-control network is inserted between the 2 halves of the selecting unit, as a convenient means of adjusting the individual channel frequencies to the proper operating level without appreciably affecting the transmission characteristic of the selecting units. A 10-db range for transmission level adjustments is provided in a continuously variable section of the level-control unit. This permits close regulation for optimum operating conditions. Fixed pads may be added to this 10-db unit, if desired. The last tuning condenser of the second section of the selecting circuit is connected in parallel with the input to the receiving channel amplifier, as an efficient means of coupling. Fig. 3 shows in schematic form the entire receiving circuit.

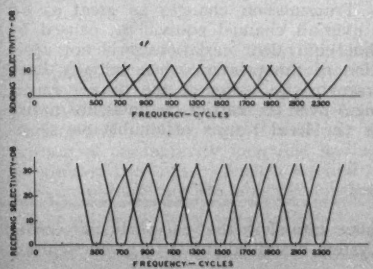

Fig. 6. (Left) Representative transmission characteristics of shaping net-works and receiving selecting circuits

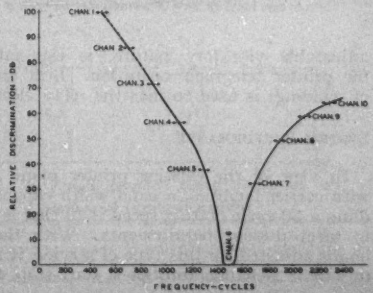

Fig. 7. (Right) Discrimination of a typical receiving selecting circuit

A vacuum tube amplifier having 2 stages of transformer coupled amplification is provided for each individual receiving channel. A maximum over-all receiving circuit sensitivity equivalent to 2.0 milliamperes down 26 to 30 db may be obtained for any of the channels. Vacuum tubes developed for these amplifiers as well as for the repeater amplifiers, have a voltage amplification factor of approximately 6 and an output impedance of 4,000 to 6,000 ohms. They require 0.45 amp filament current at 5 volts and are operated at a plate potential of 150 volts.

Conversion of the received a-c signals to d-c impulses is accomplished by means of a dry copper oxid rectifier. This rectifier is used in series arrangement between the output of the receiving amplifier and the receiving relay. Adapting this type of rectifier to conform to the requirements imposed on the receiving circuit has furnished a stable detector circuit not influenced by power supply variations. Maintenance and operating requirements for this form of detector are negligible.

For the receiving relay a sensitive, multi-winding, polarized telegraph receiving relay is used which requires a current of only a few milliamperes in the operating windings. Two other windings are connected to a local accelerating circuit in accordance with the well-known Gulstad (see "Vibrating Cable Relay," K. Gulstad, *Elec. Rev.*, London, v. 42, 1898; v. 51, 1902) vibrating relay circuit. This tends to insure positive action of the sensitive receiving relay. Furthermore the Gulstad circuit, due to its adjustable vibratory nature, is especially suited for printer telegraph operation. Still another set of windings is used to bias the relay electrically.

Fig. 8. New York terminal layout of New York-Washington carrier telegraph system

Carrier bays for 6 of the 10 channels may be seen at the right

System Performance

In view of the existing printer plant associated with carrier facilities, a band width capable of handling a 30-cycle dotting speed is all that is necessary to meet present requirements. With the channel bands adjusted for this type of service, it is possible to handle 2-channel multiplex, start-stop, or manual signals commercially. Maximum commercial traffic capability of a 10-channel system operating 4-wire on a 30-cycle basis and working a 2-channel multiplex on each carrier channel as well as on the 4 physical wires, is 3,360 words per min.; 2,400 words of this total is over the carrier. Naturally, a record communication network embodying 2 different types of printer service, along with hand speed telegraph service, thereby is limited in the number of cases where the maximum word capacity of a carrier system can be utilized. For the application at hand, it was more important to standardize the use of carrier channels capable of handling any combination of existing telegraph service used in the present plant.

For the present, carrier systems are operated over existing No. 9 AWG (114.4 mil) copper line wires. This system, even when comprising a complete complement of 10 channels will span distances from 50 to 510 miles (80.5 to 820.6 km) economically and effectively without repeaters. When repeaters are required, they may be spaced up to 275 miles (442.5 km) apart. Each amplifier of a 4-wire repeater has a maximum gain of 28 db and is capable of handling the combined outputs of all channels. Satisfactory operation over a 10-channel system has been demonstrated experimentally over artificial lines through as many as 8 repeaters in tandem, equivalent to a New York-San Francisco system.

As has been stated previously, the inherent operating characteristics of all channels are uniform. An oscillogram showing over-all telegraph transmission over a typical carrier channel is shown in Fig. 5. The telegraph signal transmitted consisted of 30-cycle reversals. The quality of the telegraph transmission may be observed by noting the freedom from bias on comparing traces A and C.

Characteristics of the transmitting shaping networks and of the receiving selecting circuits are shown in Fig. 6. Transmission curves of the receiving selecting circuits arbitrarily show relative discrimination against only the adjacent channel bands. However, the attenuation of the coupled tuned circuit type of selecting circuit employed inherently increases for departures further and further away from the resonant frequency. In order to show this more clearly a characteristic curve of a 1,500-cycle channel receiving selecting circuit is given in Fig. 7; this is typical of the other selecting circuits covering the entire frequency allocation on either side.

Inherent transmission characteristics of the over-all channels are suited particularly well to printer operation. Transmission changes as great as ±6 db in the over-all channel equivalent, caused by power or line equivalent variations, will not upset the operation of the printers when initially lined up to operate in the center of the printer range. Printer ranges over the carrier channels are nearly as good as the local ranges attainable on short-circuit.

Conclusions

Performance data show that the particular carrier telegraph system described fulfils to a practical ex-

tent the general requirements set down earlier in this article as an ideal to be approached. This should be evident when it is considered that:

1. Each carrier channel is capable of handling commercially 2-channel multiplex signals at 60 words per multiplex channel, for which speed the apparatus was initially adjusted. Only relatively simple adjustments are required to accommodate signalling speeds suitable for 3- or 4-channel multiplex operation if desired.

2. On the New York-Washington system standard 2-channel multiplex equipment has been operated at the 60-word rate on all of the 10-carrier channels without discrimination.

3. Stability of the carrier system may be judged by the lack of service interruptions over extended periods of time with a simultaneous load of 9 2-way 2-channel multiplex circuits and 1 2-way teleprinter circuit.

4. Channel equipment has been designed to provide economically a large degree of flexibility. It is possible not only to interchange equipment but, at the same time, to secure uniform telegraph transmission at all channel frequencies. These advantages are due mainly to the adjustable features incorporated in the single unit design of the shaping networks and selecting circuits.

5. The introduction of this carrier system into the telegraph plant has not imposed any additional restrictions on the inside or outside plant facilities. An example of this is the retention of the d-c 2-channel multiplex operation, with ground return, over the same wires upon which the carrier system is superimposed.

Direct Solution of Coupled Tuned Circuits

A method has been developed for computing easily and accurately the transmission characteristics of a coupled tuned circuit under practical operating conditions. While especially applicable to communication circuits, the method is said to be applicable to all circuits of this general type.

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COMMON PRACTISE today for determining the transmission properties of a selecting circuit is first to assume the circuit to be terminated in an infinite number of recurrent identical selecting circuits and then to treat it much as if it were a portion of an infinitely long line having smoothly distributed constants. Such a method has the advantage of requiring less labor than ordinarily would be involved in applying Kirchoff's laws to the circuit in place, but the assumption often leads to large errors and requires the application of several correction factors for each individual point of the transmission characteristic. The labor can be reduced substantially, however, without resorting to this assumption; the manner in which it can be done is the subject of this article. Only recurrent coupled tuned circuits employing magnetic and capacitive coupling will be treated in detail.

Full text of "Direct Solution of Coupled Tuned Circuits," presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932. *Pamphlet copies not available.*

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General Theory

The general theory will be limited to repeated identical networks operating between arbitrary terminations. Also, for convenience, the networks will be assumed to be symmetrical and composed of linear impedances, and the terminations equal to each other.

Referring to Fig. 1, let $Z = Z_X + Z_M$, first of all suppose the terminals 1–2 to be connected by short wires to 3–4. Call the current which flows I_0; then $I_0 = E/2Z_T$. The current I_0 is therefore the current which flows in the output circuit when no circuit entailing a loss is interposed. The attenuation ratio will be expressed as I_0/I where I is the output current flowing under any conditions for the same value of E. Furthermore, let a_n represent this ratio where the subscript n indicates the number of symmetrical networks interposed in any particular case; $a_0 = 1$ may be written immediately. Proceeding,

$$a_1 = \frac{E/2Z_T}{\dfrac{E\,Z_M}{(Z_T + Z)^2 - Z_M^2}} = \frac{(Z_T + Z)^2 - Z_M^2}{2\,Z_T\,Z_M}$$

Put $a_1 = A$ for the time being; by proper arrangement, then,

$a_2 = \left[\frac{2Z}{Z_M}(A) - 1\right]$ or $(BA - 1)$ where $B = \frac{2Z}{Z_M}$ and likewise $a_3 = [B(BA - 1) - A]$ and so on. In general, it may be proved that

$a_0 = 1$
$a_1 = A$
$a_2 = BA - 1 = Ba_1 - a_0$
$a_3 = B(BA - 1) - A = Ba_2 - a_1$
and
$$a_n = Ba_{n-1} - a_{n-2} = Ba_{n+1} - a_{n+2} \qquad (1)$$

Equation 1 is perfectly general for the case assumed and is an exact solution. It is the fundamental equation upon which the present method is based. It remains only to express A and B in simple terms for any particular case to establish the ease and utility of the method. This will be

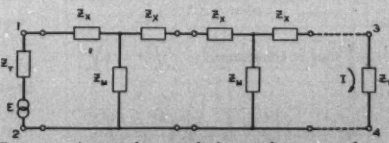

Fig. 1. A simple coupled tuned circuit of any number of identical sections

E is an arbitrarily fixed value of alternating emf but adjustable as to frequency; Z_T and Z_T are equal terminal impedances, and Z_X Z_X and Z_M included between 2 pairs of terminals compose each symmetrical network section

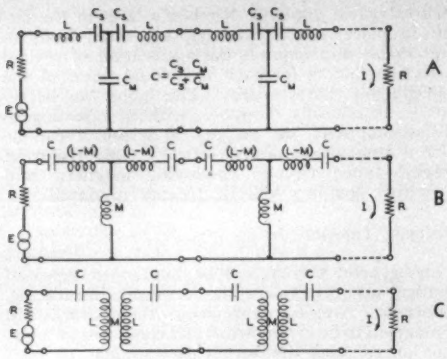

Fig. 2. Typical coupled tuned circuits

done using the well known coupled tuned circuits for illustration.

Theory Applied to Coupled Tuned Circuits

A capacitively coupled tuned circuit terminated in equal resistances R is represented in Fig. 2A. Fig. 2B and its equivalent 2C represent magnetically coupled tuned circuits likewise terminated in equal resistances R. For the time being L and C will be considered as pure reactances.

In what follows let

f = any frequency

$f_0 = \frac{1}{2\pi\sqrt{LC}}$, the frequency of series resonance

$\omega = 2\pi f$

$K = \frac{M}{L}$ and $\frac{C}{C_M}$, the coefficient of coupling

$b = \frac{f}{f_0}$ with capacitive coupling and

$b = \frac{f_0}{f}$ with magnetic coupling

$R = 2\pi f_0 M$ and $\frac{1}{2\pi f_0 C_M}$ for magnetic and capacitive coupling, respectively.

First consider the case of capacitive coupling as shown in Fig. 2A. Then

$$A = \frac{\left[R + j\left(\omega L - \frac{1}{\omega C}\right)\right]^2 + \left(\frac{1}{\omega C_M}\right)^2}{-j2R \cdot \frac{1}{\omega C_M}}$$

Note that

$\left(\omega L - \frac{1}{\omega C}\right)$ may be transformed to $\frac{1}{\omega C}\left(b^2 - 1\right)$

so that

$$A = -\frac{(b^2-1)}{K} + j\left[\frac{b}{2} + \frac{1}{2b} - \frac{1}{2b}\left(\frac{b^2-1}{K}\right)^2\right] \qquad (2a)$$

and

$$B = j\frac{\left[2\left(\omega L - \frac{1}{\omega C}\right)\right]}{-j\frac{1}{\omega C_M}} = -2\left(\frac{b^2-1}{K}\right) \qquad (3a)$$

$\left(\omega L - \frac{1}{\omega C}\right)$ may be transformed to $-\omega L(b^2 - 1)$ so that when the coupling is magnetic,

$$A = -\left(\frac{b^2-1}{K}\right) - j\left[\frac{b}{2} + \frac{1}{2b} - \frac{1}{2b}\left(\frac{b^2-1}{K}\right)^2\right] \qquad (2b)$$

and

$$B = -2\left(\frac{b^2-1}{K}\right) \qquad (3b)$$

There are a number of interesting things to observe about eqs 2a, 3a, 2b, and 3b. In the first place, nothing more is involved that the frequency ratio b and the coefficient of coupling K. This simple form is achieved without approximations. For a given value of K these equations show that the attenuation-frequency and phase shift-frequency characteristics are the same in magnitude for all values of capacity and inductance having these configurations, providing the frequency is expressed in terms of the frequency ratio b. For given values of K and b the phase shift for magnetic coupling is opposite to that for capacitive coupling. K by definition may have values from 0 to 1. In Fig. 3 are shown a family of curves for $a_1 = A$, or one coupling element with the frequency ratio b and attenuation loss in db as coordinates for several values of K. Corresponding phase shift curves are shown in Fig. 4.

It may be seen that the high or low pass selecting circuit is the special case of $K = 1$ for the magnetically or capacitively coupled circuit, respectively. The locus of critical frequency ratio also is shown. These frequency ratios are those at which the steepness of the attenuation frequency ratio curve generally passes through a maximum resulting in low attenuation decreasing rapidly to zero in one direction and increasing rapidly to higher values of attenuation in the other. Quantitatively these frequency ratios are given by setting $(b^2-1)/K = \pm 1$ since the expression occurs as a square in the case of $a_1 = A$ and in still higher powers as n is assigned higher values in $a_n = Ba_{n-1} - a_{n-2}$.

In other words $(b^2-1)/K$ becomes very small quickly when given absolute values less than 1 and increases quickly when given values greater than 1. Therefore $b_1,\ b_2 = \sqrt{1 \pm K}$ determines the critical frequency ratios which are those between which the structure transmits with little or no attenuation to the comparative exclusion of the range beyond. Similar families of curves could be shown for additional circuit sections and they would reveal a comparatively greater exclusion at the frequency ratios beyond the critical.

By substituting values of A and B found in eqs 2a, 3a, 2b, and 3b in eq 1, the magnitude and phase angle (with respect to the impressed E) of the attenuation ratio can be computed exactly and readily for values of b, K, and n. To reduce the labor still more a nomographic chart (Fig. 5) has been prepared to compute the values of the expression b^2-1/K which occurs quite frequently in the formulas for the attenuation ratios.

Let $p = \frac{b^2-1}{K}$ (4)

Substituting in eqs 2a and 3a

$$A = -p + j\frac{1}{2}\left[b + \frac{1}{b}(1 - p^2)\right] \tag{5a}$$

and

$$B = -2p \tag{6a}$$

Substituting in eqs 2b and 3b

$$A = -p - j\frac{1}{2}\left[b + \frac{1}{b}(1 - p^2)\right] \tag{5b}$$

and

$$B = -2p \tag{6b}$$

The chart in Fig. 5 may be used to solve eq 4 since a straight line connecting b and K will cut the p scale in a value which satisfies the equation.

Transmission characteristics for structures having more than one reactance network interposed may be computed by substituting in eq 1; for example

$$\left.\begin{aligned} &a_0 = 1 \\ &a_1 = -p \mp j\frac{1}{2}\left[b + \frac{1}{b}(1 - p^2)\right] \\ &a_2 = -2p(a_1) - a_0 \\ &a_3 = -2p(a_2) - a_1 \\ &\text{etc., where } A = a_1 \text{ and } B = -2p \end{aligned}\right\} \tag{7}$$

The upper part of the double sign applies to capacity coupling; the lower, to magnetic coupling. Values of a_n in general will be of complex form or $a_n = \bar{a}_n/\varphi_n$; φ_n will be the phase shift with reference to the impressed emf and $\bar{a}_n$ may be expressed in decibels, a_n (db) $= 20 \log_{10}\bar{a}_n$.

So far the structure has been assumed to be terminated in resistances R such that

$$R = 2\pi f_0 M \text{ or } \frac{1}{2\pi f_0 C_M}$$

This corresponds to the condition of maximum energy transfer at resonant frequency f_0 and should be found satisfactory in most cases. For some reason one might wish to consider other values of R. The present method can be extended quite easily to cover such cases. Call the new value R' and represent it as a function of R such that $R' = hR$. Now

$$\left.\begin{aligned} &a'_0 = 1 \\ &a'_1 = -p \mp j\frac{1}{2}\left[bh + \frac{1}{bh}(1 - p^2)\right] \\ &a'_2 = -2p(a'_1) - a'_0 \\ &a'_3 = -2p(a'_2) - a'_1 \\ &\text{etc., where } A = a'_1 \text{ and } B = -2p \end{aligned}\right\} \tag{8}$$

A set of curves is shown in Fig. 6 illustrating the effect of giving different values to h when $K = 1$. The importance of the termination in its effect on the resulting characteristic is well shown by comparing the curves for $h = 2$ and $h = 1/2$ with the one for $h = 1$. A curve for $h = \sqrt{2}$ which corresponds to a termination of $R = \sqrt{2L/C}$ is shown also to indicate the possibilities of choosing the termination to bring out a desirable shape for the transmission characteristic.

Heretofore, the coils and condensers have been considered as pure reactances; while for certain purposes it may be safe to assume this, of course it is not possible to build them without some resistance. Make this a function of R so that the resistance of one complete mesh is $r = 2dR$. Accordingly

$$\left.\begin{aligned} &a''_0 = 1 \\ &a''_1 = -p(1 + d) \mp j\frac{1}{2}\left[b(1 + d)^2 + \frac{1}{b}(1 - p^2)\right] \\ &a''_2 = -2(p + jbd)a''_1 - a''_0 \\ &a''_3 = -2(p + jbd)a''_2 - a''_1 \\ &\text{etc., where } A = a''_1 \text{ and } B = -2(p + jbd) \end{aligned}\right\} \tag{9}$$

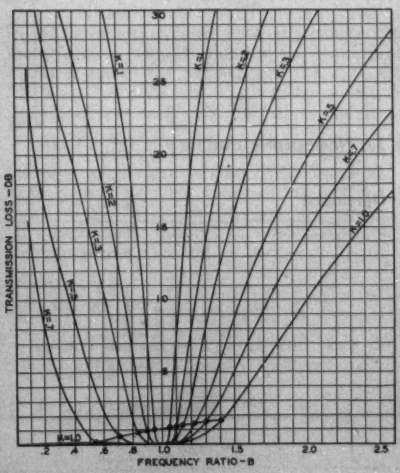

Fig. 3. (Left) Attenuation-frequency ratio curves for a tuned circuit having one coupling unit

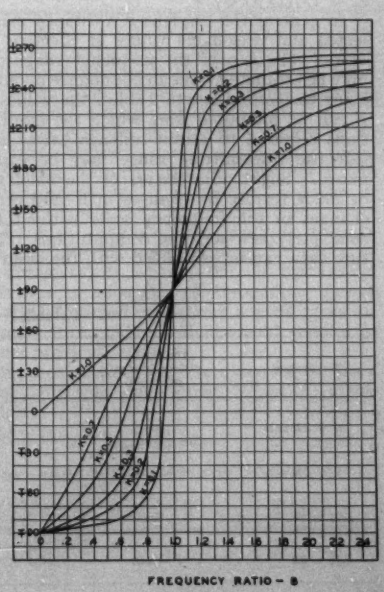

Fig. 4. (Right) Phase shift-frequency ratio curves for a tuned circuit having one coupling unit. Use upper sign for capacitive, lower sign for magnetic coupling

The effect of both dissipation and changed termination is given by

$$\left.\begin{aligned} a_0''' &= 1 \\ a_1''' &= -p(1+d) + j\frac{1}{2}\left[bh(1+d)^2 + \frac{1}{bh}(1-p^2)\right] \\ a_2''' &= -2(p+jbd)a_1'' - a_0''' \\ a_3''' &= -2(p+jbd)a_2'' - a_1''' \\ &\text{etc., where } A = a_1''' \text{ and } B = -2(p+jbd) \end{aligned}\right\} \quad (10)$$

The foregoing formulas are summarized in Table I.

Design of Coupled Tuned Circuits

The formulas just obtained immediately will suggest methods for designing actual structures for any practical case for they enable the transmission characteristics of this important class of selecting circuits to be readily investigated. To cite an example it will be assumed capacitively coupled tuned circuits are to be used. Data that might be required are, circuit impedances between which the structure will be inserted, the frequency limits between which it is desired to transmit freely, and the attenuation which must be exceeded for certain frequencies outside of the transmitting range.

Call the critical frequencies f_1 and f_2. Remembering that

$$\frac{b_1}{b_2} = \frac{f_1/f_0}{f_2/f_0} = \frac{\sqrt{1-K}}{\sqrt{1+K}}$$

the value of K and also f_0 may be calculated. Suppose the circuit impedances to be equal and represented by R. Then the coupling capacity C_M (Fig. 2A) will be found by $C_M = 1/(2\pi f_0 R)$. The value of C will be $C = KC_M$, $C_S = (C \cdot C_M)/(C_M - C)$, and $L = 1/[(2\pi f_0)^2 C]$.

In general the condenser resistance may be neglected and reasonable values of effective resistance of the coils L over the frequency range of interest may be estimated from an abundance of data. Then using the second line of Table I the values of A and B can be computed from which the number of sections required to attain sufficient attenuation outside the transmitting range may be easily determined. Slight adjustments of the band width can be made readily by changes in K and proportional changes in the frequency scale without making a completely new series of computations. The structure then can be assembled with the assurance that the transmission characteristics thus computed will agree closely with measured results.

If the impedances between which the structure is to be inserted are unequal, the inequality may be taken care of by means of a transformer having a suitable impedance ratio or by stepping the circuit impedance up or down in one or more successive meshes remembering that $Z_M = \sqrt{R_1 R_2}$ where R_1 and R_2 are the circuit impedances of the successive meshes at f_0. The condenser and inductance reactance values will be proportional to R_1 and R_2 in their respective meshes, but the transmission characteristics will remain unchanged so long as the ratio

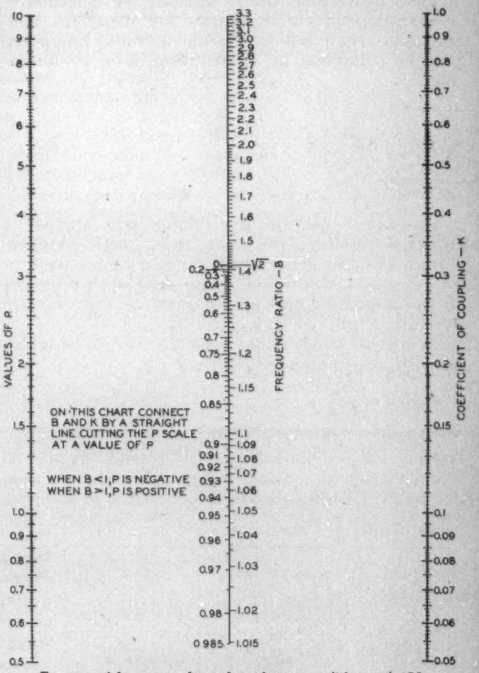

Fig. 5. Nomographic chart for $p = (b^2 - 1)/K$

Table I—Summary of Formulas Developed

Termination	Dissipation (r = resistance per mesh)	A	B	Remarks
$R = Z_M$ at f_0	No	$-p = j\frac{1}{2}\left[b + \frac{1}{b}(1-p^2)\right]$	$-2p$	$a_0 = 1$ $a_1 = A$ $a_2 = BA - 1$ $a_3 = B(BA-1) - A$ etc. $a_n = Ba_{n-1} - a_{n-2}$
$R = Z_M$ at f_0	$r = 2dR$	$-p(1+d) = j\frac{1}{2}\left[b(1+d)^2 + \frac{1}{b}(1-p^2)\right]$	$-2(p+jbd)$	
$Z_T = hR$	No	$-p = j\frac{1}{2}\left[bh + \frac{1}{bh}(1-p^2)\right]$	$-2p$	
$Z_T = hR$	$r = 2dR$	$-p(1+d) = j\frac{1}{2}\left[bh(1+d)^2 + \frac{1}{bh}(1-p^2)\right]$	$-2(p+jbd)$	

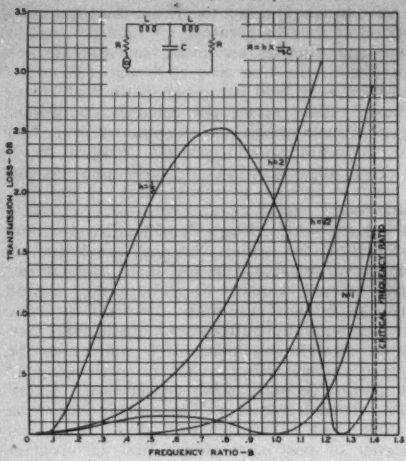

Fig. 6. (Left) Attenuation-frequency ratio curves showing effect of different terminations

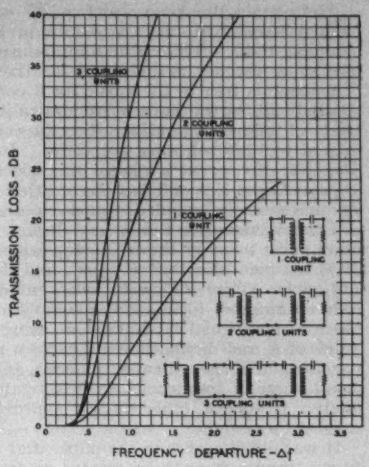

Fig. 7. (Right) Attenuation-frequency departure curves for 1, 2, and 3 coupling elements

of reactance to resistance of the different size coils is the same.

Approximations

Ordinarily, where many circuits of this kind are to be designed it would be convenient to have families of curves plotted covering the range of variables most often desired and interpolate for particular values. It might be desirable, however, to make a rough curve using approximating methods. Many ways suggest themselves but a few which may be helpful will be indicated. The loss in transmitting range, for example, may be gaged from the loss at the frequency f_0 which in the case of no dissipation is zero db. Where there is dissipation, it is very closely equal to 20 $\log_{10}[(2R + 2r)/2R]$ db since r is nearly always small compared with R. In the attenuation range r usually can be neglected. Moreover, if the attenuation is appreciable (say 10 db or more) for one section, the attenuation for additional sections will be given by adding for each additional section 20 $\log_{10}(2p)$ db to the db attenuation of one section.

It is interesting to consider the case of radio frequency tuned circuits where the fractional change in frequency over the range of interest is extremely small even though it involves traversing a comparatively large number of absolute cycles per sec. Referring to eqs 2a and 2b

$$a_1 = -\left[\frac{b^2-1}{K}\right] \pm j\left[\frac{b}{2}+\frac{1}{2b}+\frac{1}{2b}\left(\frac{b^2-1}{K}\right)^2\right]$$

Assume that $b = 1 \pm \Delta b$ and that Δb is very small compared with unity. Whence

$$\left(\frac{b}{2}+\frac{1}{2b}\right) = 1 \text{ approximately}$$

$$(b^2-1) = \pm 2\Delta b = \pm\frac{2\Delta f}{f_0} \text{ approximately}$$

Substituting

$$a_1 = -\frac{\pm 2\Delta f}{f_0 K} \pm j\left[1-\frac{1}{2}\left(\frac{\pm 2\Delta f}{f_0 K}\right)^2\right]$$

or in absolute magnitude

$$\bar{a}_1 = \sqrt{1+\frac{1}{4}\left(\frac{\pm 2\Delta f}{f_0 K}\right)^4} \text{ approximately}$$

The limiting frequencies of free transmission are derived as before by letting $\pm 2\Delta f/f_0 K = 1$. The band width is then $W = f_0 K$. Let $f_0 K = 1$ in the approximate equation and plot $\bar{a}_1$ in decibels against frequency departure Δf. Such a curve is shown in Fig. 7 for one coupling unit, but since it is symmetrical about $\Delta f = 0$ only half is drawn. To use the curve look up the attenuation corresponding to Δf and then multiply the value of Δf by the band width W which gives the actual departure in cycles per second from f_0 having that attenuation.

As a specific example, suppose it is desired to investigate the selectivity curve for a coupled tuned circuit with one coupling element such that it will transmit a band of 5 kc at a resonant frequency of 1,500 kc, i. e., from 1,502.5 kc to 1,497.5 kc. Since $W = f_0 K$, $K = 1/300$. Then multiply the abscissas of Fig. 7 by 5 kc and the curve for one coupling unit automatically becomes the selectivity curve with abscissas in kilocycles off resonance. Actual values for the coils and condensers depend upon the circuit impedance and are determined readily in the manner previously shown.

These approximations may be extended to tuned circuits of more than one section. Take 2 sections for example.

$$B = -2\left(\frac{b^2-1}{K}\right) = \frac{2\Delta f}{f_0 K} \text{ approximately}$$

In $a_2 = BA - 1$ substitute the approximate expressions for A and B, whence

$$a_2 = \left[2\left(\frac{2\Delta f}{f_0 K}\right)^2 - 1\right] \pm j - 2\left[\frac{2\Delta f}{f_0 K}\right]\left[1-\frac{1}{2}\left(\frac{2\Delta f}{f_0 K}\right)^2\right]$$

The absolute magnitude

$$\bar{a}_2 = \sqrt{1+\left(\frac{2\Delta f}{f_0 K}\right)^4}$$

Here again the band width is $W = f_0K$ and a similar selectivity curve is drawn in Fig. 7 for 2 coupling units. This curve may be used in exactly the same manner as indicated for the first curve. The same is true of the curve for 3 coupling units. Indeed, all of the curves are drawn to the same scale of frequency and are directly comparable in regard to their selecting properties. It is possible, therefore, to see at a glance the selectivity to be expected from 1, 2, or 3 sections of either capacitively or magnetically coupled tuned circuits providing K is small enough so that b need depart only slightly from unity to cover the frequency range of interest. It is assumed also that $R = Z_M$ and dissipation is negligible. They do, nevertheless, afford considerable information for a small amount of effort, since there is no special advantage in using a different value of R and dissipation will cause a more or less rounding off at the critical frequencies, an exceedingly small range of frequencies to investigate more precisely. No doubt, other ways of approximating will suggest themselves.

It was noted earlier in the paper that the coupled tuned circuits were to be treated as an example of the general scheme based upon eq 1. For other types of structures the first step would be to convert the expressions for A and B in terms of the structure into the simple form of ratios and proceed along the same line as shown here for coupled tuned circuits.

Engineering Progress—Help or Hindrance?

Engineering progress is said to be neither good nor bad; it may help man or hinder him, depending upon how it is used. This is the fourteenth article of the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

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NOT ALL progress is real gain. If we increase our needs at the same rate as we increase our facilities, there is no *real* gain. We have means to travel quickly, but why should we travel quickly? Mainly because modern life needs it; but we have to travel much more and the total delay and discomfort may be greater.

While some diseases are much attenuated, new ones are due to the new way of living. Would it be real progress to find a radical method of curing tuberculosis? Yes, given the present conditions; but are not these conditions the main reason why tuberculosis became so widespread? Surgical methods are much improved, but are most cases not due to our way of living: accidents, lack of exercise, unsuitable food?

What is happiness? If one considers his own life, he will find that the notion "happy" is relative for what makes us relatively happy for a time is not necessarily of real benefit. Real happiness should last, and can be procured only by what is really good; it is practically independent of material conditions—an abandoned, poor, sick man may be happy. Experience tells us that no *material* good has ever given true and lasting satisfaction. Every time we reach such a goal we find that it is not the thing we expected.

Experience of past ages shows that no civilization, no culture, no progress, no improved means of communication, no form of government, in short, no improvement of the outer influences, can bring peace and make man really happy. The great obstacle is man himself. He must change individually. The famous Claude Bernard used to say:

"Science has made great progress; man's passions remain the same. . . . Science does not change instinct, it reinforces it and increases its strength."

Engineering progress is neither good nor bad in itself. Engineering is concerned principally with the lower class of good. Material conditions have been much improved, particularly for the country people; but we may ask whether these conditions could not have been improved sufficiently in a more efficient way by a change in general organization even without modern progress. For the higher class of good, engineering progress may be a help, but at the same time a hindrance.

Right Use of Engineering Progress

Engineering progress and scientific discoveries show us more clearly the marvels of creation and should lead us logically to the invisible and absolute things. Many men through whom this progress was made possible could say with Faraday:

"Yet even in earthly matters I believe that the invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power of Godhead; and I have never seen anything incompatible between those things of man which can be known by the spirit of man which is within him and those higher things concerning his future, which he cannot know by that spirit."

Engineering progress helps to manifest man to himself. A child shows his childliness by choosing his sort of good; a man can likewise recognize his mental or spiritual position by what he considers as good. The way to real progress is understanding and acknowledgment of one's real position. If ex-

perience (and engineering developments are an important factor) teaches man that he is far from perfect and that his own efforts even by giving marvelous results *in their proper sphere*, cannot lift him above himself, and that he needs make use of a power belonging to a higher sphere, he will make real progress and come to real and lasting happiness.

Wrong Use of Engineering Progress

Engineering progress may hinder us from reaching the highest good. In general, modern nervous life gives fewer opportunities to examine calmly the problems of life; it draws all attention to material things. Such progress may in another way have a harmful effect. Man may consider himself as the most superior being. He may consider his achievements in the material sphere as proof of his own capabilities in any sphere of existence. He may expect to come, through culture, science, and arts, to a state of universal peace and real happiness. If he thinks this way and places himself above all, he will pass through bitter experiences; then engineering developments will have been misused. Observation shows that they often are misused; but that is the fault of man, not of engineering progress.

Great progress has been made in material things. However, as many facilities are needed by the new conditions, the final gain is not so large as may be estimated at first sight. Further, any progress in the material sphere can give only some relative and temporary happiness. Absolute and lasting happiness can have its source only outside of the human sphere and in order to attain such a state of happiness, the inner man must be changed. Material progress may help if rightly used, but also may hinder if wrongly used. Pride in his own achievements may blind man to the extent that he does not see his real needs and is kept from looking for real happiness where it can be found.

Editor's Note: Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.

Vibration in Electrical Conductors

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Laboratory tests using water as a medium indicate that the vibration of a conductor used for transmitting electric power can be diminished materially by the use of different shapes of cable cross-sections. The investigation shows further that of the various specimens tested, cables having a triangular cross-section show the least tendency to vibrate.

BECAUSE of the general increase in unit working loads as well as in the sizes of conductors on electric power transmission lines, vibration of these conductors has become a serious problem. Overhead conductor vibration probably was reported first in 1923 as deteriorating the mechanical characteristics of conductors, by some of the power companies of California. These vibrations seldom have an amplitude exceeding 2 in. Node lengths vary considerably and the frequency is of the order of from 10 to 100 cycles per sec.

Numerous mechanisms and appliances have been suggested for overcoming conductor vibrations, and some of these function very well indeed. However, such devices always are subject to the criticism that ultimately they may account for more harm than good. At the same time if the cause of the vibration can be determined, and preventives applied at the source, there will be then but little danger of trouble occurring later at some unexpected point.

Following reports of a field observation from a Pacific Coast power company, to the effect that a 3-strand cable did not vibrate as much as a standard cable,[6] also that a single strand wrapped about a cable seemed to reduce the vibration,[7] it was thought that the problem might be solved by modifying the conductor sections rather than by adding reenforcements or dampers. Studies made later by Thoma[8] confirmed this assumption, and showed that the section of the cable did play an important part in the vibration characteristics. It was thought that by upsetting the symmetry of the conductor section, eddies formed on the lee side of the conductor would be disrupted. This is explained in the following paragraphs.

Theory of Non-Symmetrical Sections

A $^{3}/_{8}$-in. diameter round rod with a $^{1}/_{8}$-in. diameter wire spiralled about it, as shown in Fig. 1, has been

Based upon "Vibration and Fatigue in Electrical Conductors" (No. 32-69) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20-24, 1932.

selected to indicate the complicated system of frequencies brought about by the eddy formation at several successive cross-sections along the cable. Balancing of the eddy forces is demonstrated at individual pairs of cross-sections. A $^{5}/_{8}$-in. plain round rod is examined also for comparison; as may be seen, there is no balancing action in this type of conductor.

Four variables that modify the resultant eddy action behind the rod and wire are introduced in each individual cross-section, namely: (1) frequency, (2) phase, (3) amplitude, and (4) neutral vibration plane. Each of these is studied in detail as follows:

1. Frequencies were calculated from the Relf and Ower[1] formula.

$$\text{Frequency} = \frac{V}{D} \times \phi\left(\frac{VD}{e}\right)$$

Assuming constant velocity of flow, the frequency is proportional to the diameter of the section; hence varying this diameter varies the frequency. In the case shown in Fig. 1, variation is brought about by spiralling the wire about the rod. The effective diameter of the combination will be the diameter of the rod plus a portion of the diameter of the wire. The diameters only were considered in determining the frequencies; theoretical curves were plotted from these values. These curves then represent, to some scale, the actual frequency of the section.

2. Phase of the vibration of an individual section is governed by the position of the outer wire and has been plotted accordingly in the diagram.

3. Force acting in the direction of vibration is,[5]

$P = KV^2 \times D$ per ft run per lb

where P = force, V = velocity, and D = diameter.

Assuming velocity constant, the force will be proportional to the diameter. The amplitude of the vibration, therefore also will be proportional to the diameter. For each section in the diagram (Fig. 1) the maximum amplitude has been plotted equal to the effective diameter and therefore represents to scale the true amplitude.

4. Vibration will take place about the center of impact of the section; this is offset from the horizontal diameter of the rod, and has been indicated in Fig. 1 by a broken line.

Eddy formation and resulting forces have been plotted for an instantaneous position of the rod and will reverse at periods according to the frequencies involved, as indicated in Fig. 1 by the double arrows for the round rod and by the double wave at cross-section 4. No attempt has been made here to establish the exact mathematical values of the quantities involved, but this is being investigated. The diagram thus illustrates the principle qualitatively, but not quantitatively.

It may be seen that at sections 3 and 7, and at 2 and 6, Fig. 1, the frequencies and amplitudes (therefore forces) are equal but are 180 deg out of phase. They will, therefore, tend to balance one another in the direction of vibration, thus reducing this objectionable feature. In the symmetrical round rod, the eddy formation is identical at each section and no balancing tendency is evident. At section 4 of the combination of rod and wire, an unstable condition is introduced due to the forces on the sections on either side of it tending to move the conductor in opposite vertical directions.

It must be realized that this discussion deals with a small length of cable and with an 8-in. lay of the wire; the 2 boundary sections are separated by 8 in. Similarly, with 3-strand cable the boundary sections would be separated by only $2^{2}/_{3}$ in. In practise it is highly probable that over such a small strata in

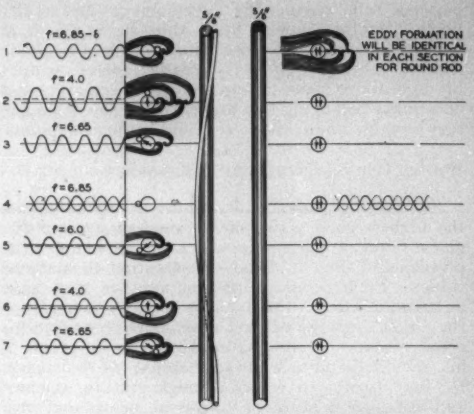

Fig. 1. Comparative study of eddy formation at the lee side of the stream flow, for uniform and non-uniform specimens

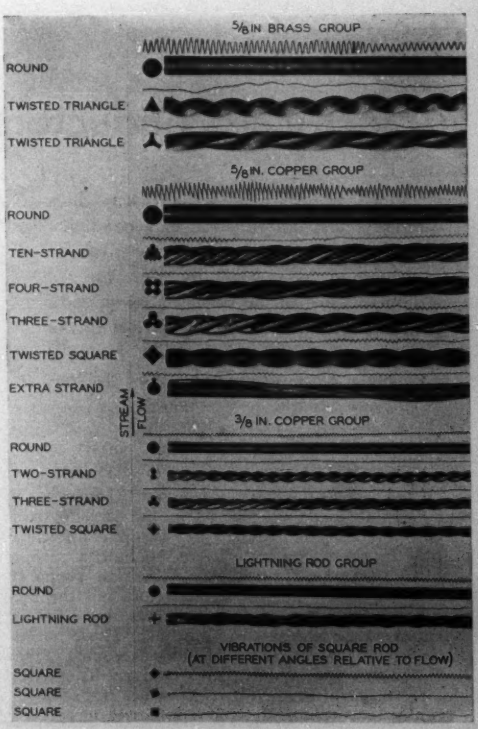

Fig. 2. Comparative vibration in water of conductors of various sections and types

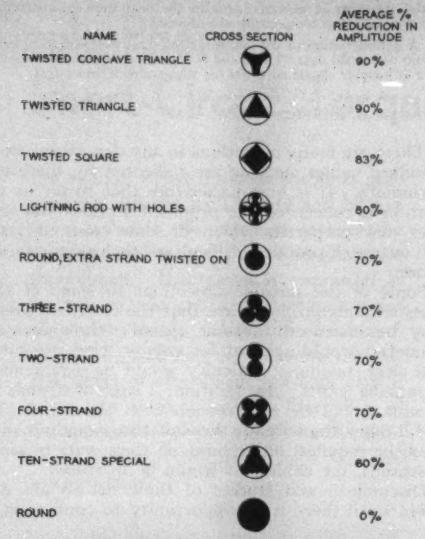

Fig. 3. Percentage reductions of vibration for conductors of different cross-sections, as observed in water

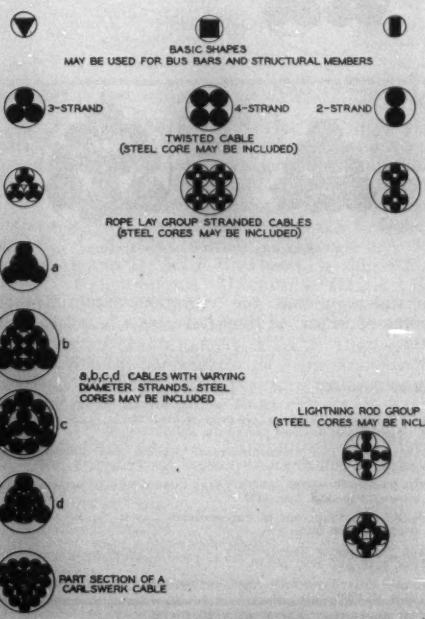

Fig. 4. Desirable cross-sections for cables and buses exposed to light winds

comparison to the length of the span, wind velocity would be approximately constant.

Special Sections Available for Study

The single wire spiralled about the rod is impracticable, for on the application of tension the load on the cable becomes eccentric. This analysis, however, points the way to modifying, in a practical way, the fundamentals of vibration in cables. For instance, in a 3-strand cable, this same complication of frequencies would be present, but the tension would be uniformly balanced over the cable section. The 4-strand cable also is a good example and is in common use, more especially in steel wire rope. Almost any sector or acorn shape may be made without much loss of mechanical strength by rolling or hammering the round cable as in 3-phase insulated cables.

As a basis upon which to work, it was decided to make specimens of sections of cables that were statically balanced so that they would not pull eccentrically. The section should, however, be unsymmetrical about the horizontal axis of the cable and at the same time be unsymmetrical for successive sections along the cable; in other words, the section should simulate those characteristics which seemed to interfere with vibration in the wire-wrapped cable. It was evident that as uniform an eddy action could not be expected over a length of these special cables as appears to be the case with standard cables or round rods, with a consequent reduction of the power input from the wind.

Laboratory Work

Experiments to determine the effect of different cable cross-sections, and the amplitude of vibration, based upon the foregoing assumptions, were carried out in the hydraulic laboratory of the University of Toronto. Experiments and methods used by Doctor Thoma were followed quite closely, water being used as a medium. Specimen conductors of various peculiar shapes were tested at 5 different velocities of water ranging from 4 to 7 in. per sec. The specimen was fastened to a flat steel strap 1 in. by $^1/_{32}$ in. and 5 ft long. This strap was used in preference to the elastic steel rod which Thoma used, as it restricted most effectively any movement in the direction of the flow of water. A light pointer attached to the strap traced the wave motion on a smoke chart attached to the drum of a vibrograph.

The specimens were divided into 5 groups, each group having a circular sample as a standard of comparison. Projected dimensions, or effective diameters, of all the specimens within each group were approximately the same, the object being to obtain the same frequencies of vibration. In order that the vibrating system in each group should be as nearly as possible the same, the specimens were made equal in weight and with centers of mass at the same point as that of the standard.

Adjustment for resonance was brought about by varying the length of the strap between the specimen and the clamp until the maximum amplitude of

vibration of the strap was obtained. Other sections in the corresponding group were treated similarly. That the required similarity was obtained was evidenced by the fact that in each group adjustment for fundamental resonance of the various samples was negligible and was seldom necessary at all so that the natural frequencies of the systems were approximately identical.

Owing to variations in the speed of the smoke chart, no exact check of the observed frequencies could be made, but the fact that no important adjustments were required within the groups indicates that approximately identical frequencies were obtained in each case. In any case, the final purpose of the experiments was to derive qualitative rather than quantitative results. The design of specimens giving the same vibrating systems within each group (i. e., having the same mechanical impedance) permitted the use of vibration amplitude as a measure of the relative damping.

Conclusions From Hydraulic Experiments

Qualitatively the following conclusions may be drawn from the experiments just outlined, pending more practical experiments using air as a medium:

1. As evidenced by the charts shown in Fig. 2, it may be seen that so far as hydraulic experiments are concerned, the twisted triangular section most satisfactorily overcomes the tendency to vibrate.

2. It can be noticed also that practically all the sections tested decreased the amplitude by at least 50 per cent compared with the round rod (Fig. 3). From the results, it would seem advisable to construct a cable having approximately a triangular cross-section. Fig. 4 shows a series of cable sections derived from the basic sections that in the laboratory evidenced a considerable reduction in tendency to vibrate.

3. If these special triangular and rectangular sections prove impracticable in cables, they still may be used in outdoor buses where difficulties of this nature may arise in the future.

Future Investigation Work

Upon the basis of these tests and the conclusions drawn, the following points are proposed or suggested for future investigation:

1. At present special cables approximating triangular cross-sections have been made and are being strung in air to see how closely the hydraulic experiments simulated practical conditions. Three sections have been suggested: (1) the ordinary 3-strand cable which was casually observed in the West as being comparatively free from vibration; (2) a 9-strand cable made up of 3 strands of 3-strand cable with rope lay; and (3) a special 9-strand cable using 2 sizes of strands, the 3 larger strands so placed in the outside layer as to give approximately the desirable triangular effect (Fig. 5). The special rope lay cable introduces a feature which may be of great importance. Due to a characteristic of the stranding, air-gaps that will not collapse under tension have been introduced. The presence of these air-gaps may serve to upset further the sequence of eddies behind the cable.

2. Acting conjointly with so-called "stiction" and "interstrand friction," the elastic properties of the individual strands of a standard cable will tend to modify the vibration. Investigation should be made with the object of segregating these and to determine the comparative importance of the damping in each case. Does interstrand friction absorb any energy at all at the comparatively long radii of curvature found in conductor vibration phenomena?

3. Experiments should be carried out to verify the following predictions made for 2 cables, (1) 6 x 0.2108, 7 x 0.0705, 266,800 cir mils A.C.S.R. "Owl"; and (2) 30 x 0.1059, 7 x 0.1059, 336,400 cir mils A.C.S.R. "Oriole." An attempt was made to predict mathematically the characteristic dimensions of vibration in these two cables and to balance energy input against energy dissipated, the remainder of the energy doing work on the cable at points of discontinuity, such as clamps. Many assumptions had to be made. Initial attempts at measurements in the field were unsatisfactory and this work was temporarily abandoned.

4. A determination of the actuating force per foot length of cable should be carried out. This could be done in a suitable wind tunnel with adjustable elastic supports for the specimen under test.

Practical Difficulties

There are many objections to any departures from standard cables such as are indicated by these experiments. It is hoped therefore that so far as vibration is concerned the proposed sections will display new properties which in some cases at least will outweigh practical difficulties, such as standardization.

Some of the possible objections to some of the cross-sections proposed are that the electrical losses may be increased to some extent; the increased diameters would account for greater wind pressures and sleet loadings; difficulty would be experienced in making joints. In addition, 2 sizes of strands in 1 cable would be a digression from the standards, and if more than 1 pass through the stranding machine be required on account of these various sizes of strands, the cable cost would be increased.

Discussions and studies of these details are deferred until there is an opportunity to confirm in a practical way that the vibration amplitudes are suppressed in air, as they have been found to be in water.

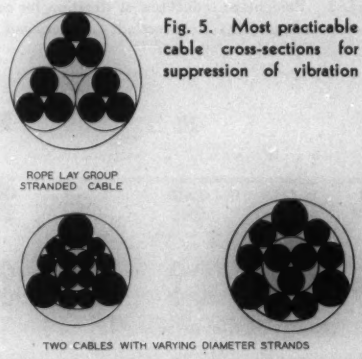

Fig. 5. Most practicable cable cross-sections for suppression of vibration

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Single-Phase Short-Circuit Torque

The analysis of synchronous machines previously published by Doherty and Nickle is expanded in this article to include the calculation of torque due to single-phase short-circuit. The torque is expressed as the sum of odd and even harmonic series which are simply related to those previously derived for the armature current. The effect of amortisseur windings also is taken into account. As an illustration of the application of the equations, the short circuit torque is calculated for a 100,000 kva generator.

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EXPRESSIONS for the single-phase short-circuit torque of a synchronous machine may be derived from previously published equations for 3-phase short-circuit torque and for single-phase short-circuit currents. These previously published equations are given in a series of articles by R. E. Doherty and C. A. Nickle (namely, SYNCHRONOUS MACHINES—I AND II, A.I.E.E. TRANS., v. 45, 1926, p. 912–42; SYNCHRONOUS MACHINES—III, A.I.E.E. TRANS., v. 46, 1927, p. 1–18; SYNCHRONOUS MACHINES—IV, A.I.E.E. TRANS., v. 47, 1928, p. 457–92; SYNCHRONOUS MACHINES—V, A.I.E.E. TRANS., v. 49, 1930, p. 700–14) particularly on "Synchronous Machines—IV" which gives expressions for the currents resulting from single phase short circuits.

As the present article is based on the theory and equations developed in "Synchronous Machines—IV," the simplifying assumptions made therein are necessarily used here. The most important of these assumptions are that:

1. Saturation is negligible.
2. The open circuit voltage is sinusoidal.
3. Armature and field resistances are negligible except in determining decrements.
4. The short circuit occurs at no load.
5. Synchronous speed is maintained during short circuit.

Based upon "Single-Phase Short-Circuit Torque of a Synchronous Machine" (32-72) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

Throughout the article all quantities are expressed in the per unit system unless otherwise noted, and instantaneous values of voltage, current, mmf, flux linkages, and torque are used.

GENERAL PROCEDURE

The synchronous machine is considered as having a main field winding in the direct axis and amortisseur windings in both the direct and quadrature axes, thus introducing both subtransient and transient reactances. The general procedure employed in "Synchronous Machines—IV" is used to determine armature current and rotor excitation, except that 3-phase line-to-neutral reactances are used in place of single phase static reactances.

The values of the armature current and mmf, before the effect of the decrements is appreciable, are determined by the open circuit armature voltage, e_o, the position of the rotor when short circuit occurs, and the subtransient reactances. The armature mmf is resolved into components over the direct and quadrature axes and is expressed in terms of odd and even harmonic series. The fundamental of the odd series current induces a transient direct current in the direct axis rotor circuits; all other harmonic components induce alternating currents in the rotor windings. Consequently, on short circuit the d-c rotor excitation is increased from the value existing just before short circuit to a new value which includes a component induced in the 2 direct axis rotor windings by the armature current. The decay of the induced d-c components of excitation and that of the odd series component of the armature current are determined by the decrement factors of the rotor windings in the direct axis.

It is assumed that the decay of the unsupported rotor excitation may be represented with sufficient accuracy by 2 decrement factors, one applying to the decay of induced direct currents in the amortisseur winding, and the other applying to the decay of that part of the d-c component of field current which the exciter does not maintain. The "rotor linkage factor," F, represents the total rotor linkages at any time after short circuit, as a fraction of the rotor linkage just before short circuit. The following equation gives F as a function of time, in terms of machine constants:

$$F = \frac{x_d'' + x_2}{x_d + x_2} + \frac{(x_d'' + x_2)(x_d - x_d')}{(x_d + x_2)(x_d' + x_2)} \epsilon^{-\sigma_f' t} + \frac{x_d' - x_d''}{x_d' + x_2} \epsilon^{-\sigma_f'' t} \qquad (1)$$

where

x_d = direct axis synchronous reactance
x_d' = direct axis transient reactance
x_d'' = direct axis subtransient reactance
x_q'' = quadrature axis subtransient reactance
x_2 = negative sequence reactance $= \sqrt{x_d'' x_q''}$
σ_f' = the decrement for the unsupported linkages in the main field, with the armature short-circuited single-phase $= \frac{x_d + x_2}{x_d' + x_2} \sigma_o'$
σ_o' = the decrement for unsupported field linkages with the armature open circuited
σ_f'' = the decrement for induced direct currents in the amortisseur on single phase short circuit $= \frac{x_d'' (x_d' + x_2)}{x_d' (x_d'' + x_2)} \sigma_o''$

σ_a'' = the amortisseur winding decrement for 3-phase short-circuit at the machine terminals
(Since in the per unit system time is measured, not in seconds, but in electrical radians traversed at the normal frequency, f, the decrements above are $1/(2\pi f)$ times the reciprocals of the respective time constants in seconds.)

The linkages in the short circuited armature winding are maintained, at the instant just after short circuit, by the induced d-c component of armature current. These linkages must decay with the d-c component of armature current. For convenience, an "armature linkage factor," A, is introduced. It represents the linkages of the short circuited armature winding at any time after short circuit as a fraction of the maximum linkages of that winding before short circuit. As shown in "Synchronous Machines—IV," the even series components of armature current and the odd series components of rotor excitation are proportional to the d-c component in the armature, so that their decay is also represented by the armature linkage factor, A.

The expression for this factor is

$$A = \epsilon^{-\sigma_a t} \cos \alpha \tag{2}$$

where

$$\sigma_a = \frac{3(k^2+1)}{4k^2} \frac{r}{x_2}$$

k = 1, for line-to-neutral short circuit
$k = \sqrt{3}$, for line-to-line short circuit
r = the per unit armature resistance, line-to-neutral
α = angular position of the direct axis at the instant of short circuit, measured in the direction of rotation from the axis of the armature winding

Inserting the armature and field linkage factors A and F, respectively, in equations which are given in "Synchronous Machines—IV," the armature current at any time after single phase short circuit may be expressed in finite trigonometric form, as follows:

$$i = \left(\frac{3}{2k}\right) \frac{2e_o[F \cos (t+\alpha) - A]}{H} \tag{3}$$

where

e_o = armature voltage before short circuit
$H = (x_d'' + x_q'') + (x_d'' - x_q'') \cos 2(t+\alpha)$

The equivalent Fourier series expansion is:

$$i = \frac{3}{2k}\left[\frac{2e_oF}{x_d'' + x_2}\mathbf{O} - \frac{e_oA}{x_2}\mathbf{E}\right] \tag{4}$$

where

$$\mathbf{O} = \text{odd series} = \frac{(x_d'' + x_2)\cos(t+\alpha)}{H}$$
$$= \cos(t+\alpha) + b\cos 3(t+\alpha) + b^2 \cos 5(t+\alpha) + \ldots$$
$$= \sum_{n=1,3,\ldots} b^{\frac{n-1}{2}} \cos n(t+\alpha)$$
$$\mathbf{E} = \text{even series} = \frac{2x_2}{H}$$
$$= 1 + 2b\cos 2(t+\alpha) + 2b^2 \cos 4(t+\alpha) + \ldots$$
$$= 1 + \sum_{n=2,4,\ldots} 2b^{\frac{n}{2}} \cos n(t+\alpha)$$
$$b = \frac{\sqrt{x_q''} - \sqrt{x_d''}}{\sqrt{x_q''} + \sqrt{x_d''}} = \frac{x_2 - x_d''}{x_2 + x_d''}$$

The short circuit torque is expressed in terms of the components of armature current and rotor excitation in the direct and quadrature axes. The expression in finite trigonometric form is

$$T = -\frac{2e_o^2F[F\cos(t+\alpha) - A]\sin(t+\alpha)}{H} + \frac{2e_o^2(x_d'' - x_q'')[F\cos(t+\alpha) - A]^2 \sin 2(t+\alpha)}{H^2} \tag{5}$$

For the case of zero initial armature linkages, $\alpha = \pi/2$ and the above expression reduces to

$$T = \frac{2e_o^2 x_q'' F^2 \sin 2t}{H^2} \tag{6}$$

The torque, expressed as the sum of odd and even harmonic series, is

$$T = \frac{e_o^2}{x_2 + x_d''}\left\{2FA\sum_{n=1,2,\ldots} nb^{\frac{n-1}{2}} \sin n(t+\alpha) - \left[F^2\frac{x_2}{x_2 + x_d''} + A^2\frac{x_2 - x_d''}{x_2}\right]\sum_{n=2,4,\ldots} nb^{\frac{n-2}{2}} \sin n(t+\alpha)\right. \tag{7}$$

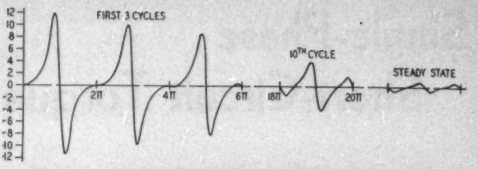

Fig. 1. Single-phase short-circuit torque of a 100,000-kva alternator, maximum initial armature linkages

$$\text{Torque} = -\frac{2F(F\cos t - A)\sin t}{H} - \frac{0.438(F\cos t - A)^2 \sin 2t}{H^2}$$
$$= 5.25\,FA(\sin t + 0.669\sin 3t + 0.249\sin 5t + \ldots) - (3.21\,F^2 + 1.92\,A^2)(\sin 2t + 0.446\sin 4t + 0.149\sin 6t + \ldots)$$
$$F = 0.449 + 0.417\epsilon^{-0.0021t} + 0.134\epsilon^{-0.069t}$$
$$A = \epsilon^{-0.026t}$$
$$H = 0.515 - 0.219\cos 2t$$

Summary of Results

The per-unit single-phase short-circuit torque is

$$T = \frac{2FAe_o^2}{x_2 + x_d''}\{\sin(t+\alpha) + 3b\sin 3(t+\alpha) + 5b^2\sin 5(t+\alpha) + \ldots\} - \frac{e_o^2}{x_2 + x_d''}\left[F^2\frac{x_2}{x_2 + x_d''} + A^2\frac{x_2 - x_d''}{x_2}\right]\{2\sin 2(t+\alpha) + 4b\sin 4(t+\alpha) + 6b^2\sin 6(t+\alpha) + \ldots\} \tag{8}$$

From an inspection of this equation it appears that the odd harmonic components of torque are due to the interaction of rotor and armature magnetic fields and that these components disappear as the trapped armature linkages die out. For the case of a short circuit with zero initial armature linkages no odd harmonic torques are present.

A part of the even harmonic torque is proportional to the square of the armature linkages and this part disappears when the subtransient reactances in the

direct and quadrature axes are equal. This may be considered as a "reluctance torque" due to the variation in the permeance which the rotor offers to the trapped armature flux. Likewise, the part of the torque which is proportional to the square of the rotor linkages is due to the variation in the permeance which the armature offers to the rotor flux.

It is interesting to note that immediately after a short circuit with maximum armature linkages, the maximum value of second harmonic torque due to the field linkages alone is $x_2/(x_2 + x_d'')$ times the maximum fundamental torque, while the maximum value of second harmonic torque due to armature linkages alone is $(x_2 - x_d'')/x_2$ times the maximum fundamental torque. The maximum value of total second harmonic torque just after a short circuit with maximum armature linkages is $(2x_q'' - x_d'')/(x_q'' + x_2)$ times the maximum value of fundamental torque. This ratio varies from 0.5 for $x_d'' = x_q''$ to 1.25 for $x_d'' = 0.2\ x_q''$. Thus the maximum values of fundamental and second harmonic torque are of comparable magnitude just after short circuit.

Since the armature linkages eventually disappear, the steady state torque is made up entirely of even harmonic components.

Example of Calculations

To illustrate the use of the formulas developed, numerical results have been calculated for a 60-cycle testing generator rated at 100,000 kva. The per unit constants of the machine, as determined by test, are as follows:

$x_d = 0.615$;	$x_d' = 0.207$;	$x_d'' = 0.148$
$x_q = 0.412$;	$x_q' = 0.412$;	$x_q'' = 0.367$
$\sigma_a = 0.025$;	$\sigma_f' = 0.0021$;	$\sigma_f'' = 0.069$

(x_q = quadrature axis synchronous reactance; x_q' = quadrature axis transient reactance)

Hence $x_2 = 0.233$; $b = 0.223$

Figs. 1 and 2 show the line-to-line short-circuit torque with maximum initial armature linkages and zero initial armature linkages, respectively, as computed from the formulas derived.

From the standpoint of mechanical design of the machine and its foundations, the condition which gives maximum torque is the most important. It is evident that for this purpose it is sufficient to consider the torque with maximum initial armature linkages. In the case of the machine considered, the peak value of torque under this condition is nearly 12 times full load torque. It is to be noted that this high peak value is largely due to the presence of trapped armature linkages, since with no armature linkages the peak value of torque is only 4 times normal.

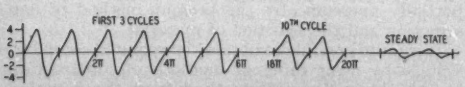

Fig. 2. Single-phase short-circuit torque of a 100,000-kva alternator, zero initial armature linkages

$$\text{Torque} = \frac{0.734\ F^3 \sin 2t}{H^3}$$

$$= 3.21\ F^3 (\sin 2t - 0.446 \sin 4t + 0.149 \sin 6t - \ldots)$$

$$F = 0.449 + 0.417e^{-0.0031t} + 0.134e^{-0.069t}$$

$$H = 0.515 + 0.219 \cos 2t$$

The trapped armature linkages are also responsible for all odd harmonic components of torque. Fig. 2 shows that with no trapped armature linkages the torque is made up entirely of even harmonics and in Fig. 1 it is seen that the odd harmonics decay gradually so that the torque curve approaches that of Fig. 2.

It appears from the eqs 5, 6, and 7 that the short circuit torque is the same for line-to-line and line-to-neutral short circuits. This is exactly true for an ideal machine and is true for actual machines provided that $x_0/2$ is negligible in comparison with x_d'' and x_q'' (x_0 = zero sequence reactance). Although the armature currents resulting from the two types of short circuit of an ideal machine are different, the armature mmfs are the same.

The consideration of machine losses would somewhat modify the torque as calculated in this article. The correction for losses can be calculated approximately in a given case, but this correction is generally small enough to be neglected.

Motorized Pumps for Fuel Oil Trucks

INCREASING popularity of modern oil burners for heating purposes has resulted in a greatly increasing demand for fuel oil. Distribution of oil suitable for heating always has been a perplexing problem for this heavy oil must be pumped from the delivery vehicle to the customer's tank, even though the tank is below the level of the vehicle.

The delivery problem has been somewhat simplified and the delivery time greatly reduced by the Suburban Fuel Oil Service, Inc., Mount Vernon, N. Y., by replacing the mechanical pump drive with an electrical drive on one of its trucks, a 21-ton 6-wheel tractor-trailer type with a capacity of 3,000 gal. Originally the centrifugal pump with which this truck was equipped was mounted on the tractor; it was connected directly to a 4-speed power take-off on the transmission of the truck. In making a delivery 2 hoses had to be connected necessitating 4 hose connections in all.

In making the change to electrical drive, the pump was removed from the tractor and placed next to the tank on the left underside and is now driven through a silent chain drive by a 3-hp shunt motor. On the tractor the power take-off shaft was extended and, by means of a heavy duty silent chain, now drives a 3-hp

Prepared especially for Electrical Engineering from information contributed by Mark W. Copeland (M'31) consulting engineer, Westchester Sign Display Company, Bronx, N. Y.

shunt generator. A small 1/4-hp compound-wound generator mounted near the main generator and driven by the power take-off shaft with a V belt, supplies constant field current to the motor and, through a specially designed rheostat, supplies variable field current to the generator. This rheostat provides the only control necessary both to start and stop the motor, and to vary the pump speed from about 15 to 375 rpm, its maximum rated speed. For the "off" position this rheostat circuit is simply opened, the armatures of the motor and generator being solidly connected together through a circuit breaker. With this arrangement but small currents, rarely exceeding 1 amp at 220 volts, are handled in the control circuit. Meters are provided to indicate directly (1) load in per cent of motor capacity, (2) pumping rate in gallons per minute, and (3) generator speed; the meter dials are illuminated for night operation.

Curves in Fig. 2 show delivery time before and after the pump was equipped for electrical operation; these are on the basis of 3,000-gal loads, with the number of deliveries per load plotted against time required for making hose connections and for pumping. In addition to the reduction in delivery time, the number of hose connections per delivery has been reduced from 4 to 1, the only connection necessary being that to the customer's tank. The truck has been in operation 24 hr per day for the past 8 months, without one failure. It is said to be the first and only truck equipped for pumping oil by this method.

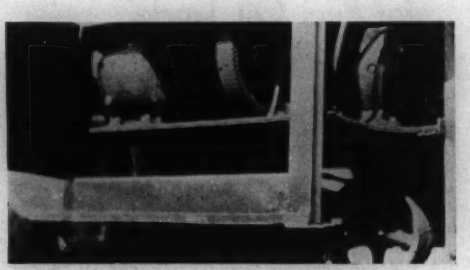

Fig. 1. View of electrically driven pump showing method of mounting

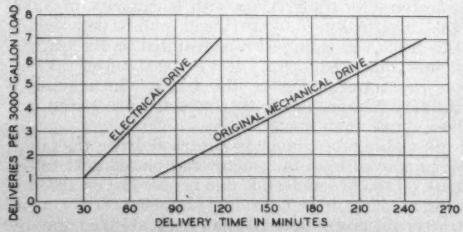

Fig. 2. Oil delivery time (No. 3 oil) before and after pump was equipped for electrical operation

Maximum pumping rate with original drive, 70 gpm; with electrical drive, 200 gpm

Transformers With Peaked Waves

Special purpose transformers now can be built to provide a secondary voltage wave less than 2 electrical degrees wide from a sinusoidal primary voltage source. The construction of such a transformer and some of its uses are described in this article.

By
O. KILTIE
ASSOCIATE A.I.E.E.

General Elec. Co.
Fort Wayne, Ind.

ONE OF THE MOST RECENT developments in transformer design is that of a transformer with an extremely narrow secondary voltage wave. A peaked secondary voltage wave transformer may be defined as a transformer providing a narrow secondary voltage wave from a sinusoidal primary voltage source. The minimum width of wave thus far obtained is between 1 and 2 electrical degrees measured at 1/2 of the maximum amplitude. However, the transformer can be designed for almost any width of wave above this value up to a limit of approximately 90 electrical degrees. These transformers have been produced during the last few years and are now available for commercial application.

Transformers of this type originally were designed and developed for stroboscopes in 1927 by C. A. Nickle (General Electric Company, Schenectady, N. Y.); in 1928 they were applied to thyratron (a grid controlled mercury vapor tube) inverter circuits. Since that time these transformers have been found to serve very well as component parts of frequency meters and tachometers.

Design of these transformers is somewhat different from that for other transformers. One of the vexing problems during the past with saturated type transformers has been the inherently high primary burden required from the supply source. This has been partially overcome by the present method of construction and the selection of material.

It is quite possible to obtain the required secondary voltage by using different methods of construction, but the most desirable method from the manufacturing point of view is that shown by Fig. 1. Before proceeding with the details of construction and operation, however, an explanation should be made of the fundamental object in the design. It is desired to

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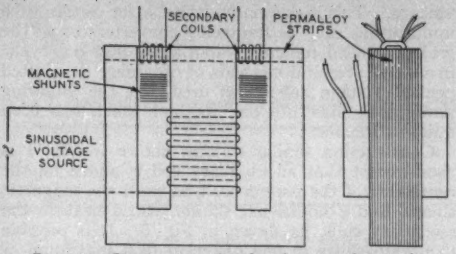


Fig. 1. Construction details of a transformer for peaked secondary voltage waves

saturate the secondary core section to a certain degree depending upon the required width of secondary voltage wave. With this condition the core section for the primary winding should not be saturated. To produce the peaked secondary voltage the secondary core material must possess a very steep magnetization curve below the knee, and beyond the knee it should be as nearly a horizontal line as possible. Permalloy (an alloy of nickel and iron) properly heat treated satisfies these requirements best.

In the type of construction shown in Fig. 1, the main core is comprised of the economical type of "E" punchings; these punchings are made from regular silicon steel, a material which can be operated at a flux density just below saturation. The primary coil is assembled onto the center leg of the core. Laminated magnetic shunts of the proper cross-section and length to permit a low reluctance are placed in each "window" between the primary and secondary coils. It is necessary that these shunts be of proper dimensions so that they will pass all of the flux not forced through the permalloy secondary core section for reasons explained later. In attempting to obtain the narrowest waves, permalloy strips 0.014 in. thick originally were used; these were placed across the open end of the "E" punchings. Later it was found that for a given cross-section of permalloy 0.0045-in. laminations produced a narrower wave than laminations of 0.014-in. thickness. However, unless an extremely narrow wave is essential the 0.0045-in. material should not be used, because of its more delicate and expensive character.

By making its cross-sectional area much less than that of the silicon steel, the permalloy core section must become saturated very quickly, providing the silicon steel section is operating at a density just below the knee of its magnetization curve. Since the magnetization curve for permalloy is quite flat after saturation is reached it is possible to keep the zero portion of the secondary voltage to a straight line. This portion of the wave must be held to zero throughout the entire period of time between alternate secondary peak waves, in order to meet the requirements of certain practical applications of the transformer.

From Fig. 2 it can be seen that the width of the secondary voltage wave is dependent upon the extent of magnetization of the permalloy core section or upon the amplitude of the secondary flux wave Φ_{sec}. During the saturated period there is no change of flux; consequently, the secondary voltage must be 0 during that period. The flux changes rapidly from the positive saturated condition to the negative saturated condition producing a peaked voltage wave, which is equal in width to the angle θ. If the air-gap be too large or the secondary coil build too high, there will be a fringing of flux through the coil; this flux cannot pass through the permalloy because of its saturated condition. As a result the peaked voltage will contain a superimposed sine wave component voltage, the amplitude of which possibily could be a considerable fraction of the maximum amplitude of the peaked voltage wave. Obviously, it is advisable to avoid this component.

Extremely narrow waves could be obtained more easily by using a primary flux wave having a flat top and very steep sides; this is because the flux changes more rapidly in a wave of that sort than in a sine wave. Such a flux wave could be obtained by using an additional transformer between the source of supply and the peaked voltage transformer.

Wave shapes of the peaked voltage transformers have decidedly good features such as steep sides, flat top, and a straight line zero portion. As one might expect, they do not take the shape of a "saw tooth" or of a wave having a form factor of approximately 1.6. The true shape can be seen from Fig. 2, and from actual oscillograms reproduced in Fig. 3. Variations in the supply voltage alter the width of the wave but slightly.

The burden taken by a transformer having a 2° wave required only 0.15 amp exciting current and 1.5 watts at 110 volts and 60 cycles; if necessary, even this small burden can be reduced. Characteristic curves for a typical transformer under different conditions are shown in Fig. 4.

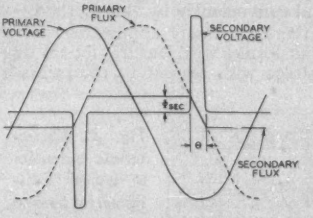
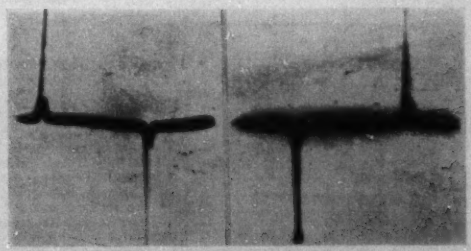


Fig. 2. Voltage relations in the peaked-voltage transformer

Fig. 3. (Below) Oscillograms of the transformer secondary voltage



100-volt 60-cycle waves approximately 3° wide (left) and 10° wide (right) at half maximum amplitude

Recognition should be given to B. D. Bedford (General Electric Company, Schenectady, N. Y.) for his original work on this type of transformer and for his valuable suggestions during the development.

Uses for the Peaked Voltage Transformer

As mentioned previously, one of the earliest applications of the peaked secondary voltage wave transformer was in inverter circuits using the grid-controlled mercury vapor tube. A peak voltage is essential for excitation circuits of this tube for several reasons:

1. In certain circuits peaked excitation causes the phase position of the initial excitation to be independent of the time the switch is closed.

2. In many tube circuits the excitation period must be short. For example, in inverter circuits the excitation period of a tube should be at least as short as its conducting period.

3. A very steep wave front for grid excitation has the advantage over other wave forms since any change in grid potential or tube characteristics will have small effect on the time of excitation.

4. In frequency changers using this tube the low frequency excitation may be used to turn on and off the high frequency excitation by means of a transformer with a peaked secondary voltage wave.

Since many new circuits for the grid controlled mercury vapor tube are being developed continually, it is thought that this type of transformer will be used extensively in this field because it can serve as an essential component part in many of the circuits.

A combined transformer with peaked secondary voltage and neon lamp furnish the essential component parts of a good stroboscope. If the viewing is done through a narrow slot in the stroboscope disk, the width of the light spot on the disk will be dependent upon the width of the secondary voltage wave from the supply transformer. The spot will be very narrow with the use of a 5° voltage wave and also very sharp. Synchronous characteristics or the phase displacement between 2 voltage waves can be viewed readily and conveniently by this method.

It seems that there are many applications for a peaked voltage transformer with features for shifting the secondary voltage with respect to the primary voltage. This is especially desirable for certain tube applications such as frequency converters using the grid controlled mercury vapor tube, and polycyclic inverters. Several methods of obtaining the shifted peaked voltage have been used, but the following paragraphs illustrate one method which has been quite satisfactory.

Construction similar to that shown in Fig. 1 is used except that an auxiliary coil is added on the center leg of the core spaced between the magnetic shunts and 2 additional shunts placed next to the secondary coils, as shown in Fig. 5. It is possible to obtain shifts in one direction to a maximum of 135 electrical degrees. Several units were built having a 40-volt peaked wave with a width of approximately 4°, shifted only 90° away from the primary voltage instead of the usual 180°. Although a small shift can be obtained by connecting the auxiliary coil so that its mmf aids that of the main coil, the maximum shift is obtained by connecting this coil so that its mmf opposes that of the main coil, when both are connected to the same source of supply voltage. Some means of control must be used to vary the auxiliary coil mmf so that the desired variation in the angle of shift can be obtained. Best results are obtained by using a variable series resistor instead of an inductor or condenser to vary the amount of current in the auxiliary coil. It can be seen that the change of resistance in the one circuit varies the voltage across the auxiliary coil, and this is accompanied by a change of the magnetizing current in the primary coil. Such a combination causes the mmf's of the 2 coils to be out of phase with each other and to produce a fundamental mmf out of phase with the primary voltage. The permalloy section of the core of course conducts only the displaced flux and consequently the peaked secondary voltage is displaced accordingly from the primary voltage.

The burden required for such a device is not excessive. Those units of this type to which reference was just made required only 13.5 va at 90 volts and 50 cycles. With increases in phase shift the burden is increased, but it is quite probable that for most purposes a shift greater than 90° is not necessary. Amplitude, width of wave, and phase displacement of the peaked secondary voltage waves are not changed appreciably by large variations of the primary voltage.

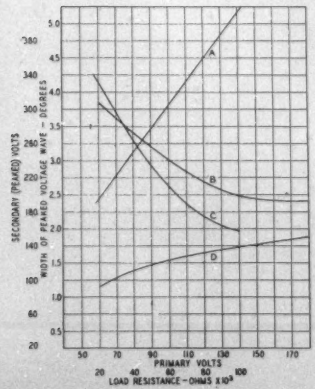


Fig. 4. Characteristic curves for a typical transformer for peaked voltage

A—Secondary peak volts vs primary volts
B—Width of wave vs load resistance
C—Width of wave vs primary volts
D—Secondary peak volts vs load resistance
Curves A, B, and C are for both secondary coils in series; Curve D is for one secondary coil with the other coil open (see Fig. 1)

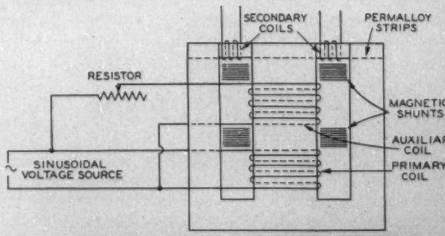


Fig. 5. Construction of peaked-voltage transformer with provisions for shifting the phase relations of the secondary and primary voltages

News

Of Institute and Related Activities

Cables, Water Power, Dominate Baltimore Sessions

OF THE 4 regular sessions of the Middle Eastern District meeting held Oct. 10–13, 1932, at the Lord Baltimore Hotel in Baltimore, Md., one was given over to 4 papers dealing with power cables, one to 3 papers concerned with communication cables, and 2 to the presentation of 6 papers devoted to hydroelectric subjects including delivery and distribution of power so generated. Meeting jointly with the Institute for the first 2 (cable) sessions, was the National Research Council's committee on electrical insulation which functions under the leadership of Dr. J. B. Whitehead. This latter committee subsequently held 3 independent sessions in Maryland Hall on the Johns Hopkins campus, but otherwise participated in the general activities of the meeting. The Institute's board of directors also met in conjunction with the meeting, as reported elsewhere in this issue.

Analysis of Attendance at Baltimore

Classification	Baltimore	Dist. No. 2	Dist. No. 3	Dist. No. 1	Misc.	Totals
Members	76	50	33	18	18	195
Men Guests	13	13	1	2	4	33
Women Guests	6	2	3	1	0	12
Totals	95	65	37	21	22	240

Registration totaled 240, classified as indicated in the accompanying tabulation, a turn-out that paid tribute to the general interest value of the technical program presented by the Baltimore meeting committee. Further response to the program's appeal was evidenced by the attendance at the individual sessions, ranging from 125 to 180, and by the discussions, which were distinctly above the average in quality and in quantity. The various activities which were coordinated during the 3 days of the meeting evidently exerted a favorable influence upon the attendance from points relatively remote from Baltimore.

Technical Sessions

Allowing Monday morning, for the convenience of late arrivals, for registration, and for a District executive committee meeting (reported elsewhere in this issue) the technical sessions were held Monday afternoon, Tuesday morning, and Wednesday morning and afternoon as outlined in the program published on p. 664 of Electrical Engineering for Sept. 1932. Presiding at these sessions were, respectively, Dr. J. B. Whitehead, dean of engineering at The Johns Hopkins University, Baltimore, Md.; J. L. D. Speer, Jr., chief engineer, Chesapeake & Potomac Telephone Company of Baltimore City, Md.; A. F. Bang, superintendent of operation, Pennsylvania Water & Power Company, Baltimore, Md.; and J. R. Baker, operating engineer, Pennsylvania Water & Power Company, Baltimore, Md.

Organized inspection trips provided for visits to points of timely interest in the vicinity of Baltimore. On Monday evening a group visited the plant of the Locke Insulator Company where, after a brief turn of inspection through the factory, a demonstration of an interesting and spectacular nature was staged in the company's 3,000,000-volt laboratory. One of the Tuesday afternoon trips included visits to 2 local steam-electric generating plants and to the Baltimore terminal substation of the Safe Harbor 230-kv transmission system. As an alternate to this trip, others visited the Western Electric Company's insulated wire mill and cable plant and the nearby factory of the General Aviation Company. All day Thursday was given over to a trip to the Safe Harbor hydroelectric plant of the Pennsylvania Water & Power Company. A special car was handled on regular Pennsylvania trains between Baltimore and Perryville, Pa., then to and from the plant by a special locomotive. Ample time was available for a thorough inspection of the plant and all of its associated structures. Luncheon was served at the plant by the power company.

Entertainment

Entertainment features provided were simple in character, but nicely rounded out the meeting program. Women guests were taken Tuesday afternoon to the United States Naval Academy at Annapolis where they were shown the sights and subsequently served with tea at Carvel Hall. An informal sight-seeing trip and tea also were provided for the women Wednesday afternoon.

At an informal gathering Tuesday evening, with Dr. W. B. Kouwenhoven, A.I.E.E. vice-president for the Middle Eastern District, presiding, President Charlesworth presented certificates and prizes to W. P. Taylor of Baltimore who won both the initial-paper prize and the best-paper prize for his District for 1931 as reported on p. 418 of Electrical Engineering for June 1932. Subsequently called upon to address the gathering, President Charlesworth gave public recognition of the work done by the personnel of the local meeting committees, and spoke briefly upon Institute affairs in general. He called attention to the fact that the Institute for more than 48 years has devoted its efforts to the furtherance of the ideal laid down by its founders in 1884: "the advancement of the theory and practice of electrical engineering and of the allied arts and sciences, the maintenance of a high professional standing among its members, and development of the individual engineer." President Charlesworth also outlined briefly the various successive steps in broadening the Institute's services to its members—through the formation and development of local Sections and subsequently of Student Branches, and in recent years the extension of regional activities including District conventions. Current problems came up for brief mention, too, as he cited the efforts of the finance committee and the headquarters staff in attempting to meet the rigorous requirements of a substantially reduced budget without impairment to the Institute's more important services to its members. President Charlesworth bespoke support and cooperation for the national officers and the office staff in their efforts to cope with the present situation. Following this, Dr. Adolph H. Shultz, associate professor of physical anthropology at The Johns Hopkins University, delivered an enlightening and challenging illustrated lecture, "Man as a Primate," in which he presented excerpts from a mass of data revealing close similarities between man and the higher forms of anthropoids, notably the orang-utan, the chimpanzee, and the gorilla.

Culminating the social activities of the Baltimore meeting was the dinner-dance held at the Lord Baltimore Hotel, Wednesday evening.

November 15 Last Date for Suggesting Nominations

Actions specified in the Institute's constitution and by-laws relative to the organization of a national nominating committee are being taken, and the meeting of the national nominating committee for the nomination of officers to be voted upon at the election in the spring of 1933 will be held between November 15 and December 15, 1932. All suggestions for the

consideration of the national nominating committee must be received by the secretary of the committee at Institute headquarters, New York, N. Y., not later than November 15, 1932.

A.I.E.E. Directors Meet at Baltimore

A regular meeting of the board of directors of the American Institute of Electrical Engineers was held at the Lord Baltimore Hotel, Baltimore, Md., on Wednesday, October 12, 1932, during the Institute's Middle Eastern District meeting.

Present were: *President*—H. P. Charlesworth, New York, N. Y.; *Past-presidents*—W. S. Lee, Charlotte, N. C.; C. E. Skinner, East Pittsburgh, Pa.; *Vice-presidents*—W. W. Freeman, Lexington, Ky.; J. Allen Johnson, Buffalo, N. Y.; W. B. Kouwenhoven, Baltimore, Md.; P. H. Patton, Omaha, Neb.; *Directors*—L. W. Chubb, East Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; B. D. Hull, Dallas, Tex.; A. E. Knowlton, New York, N. Y.; G. A. Kositzky, Cleveland, Ohio; A. H. Lovell, Ann Arbor, Mich.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y.; A. C. Stevens, Schenectady, N. Y.; H. R. Woodrow, Brooklyn, N. Y.; *National treasurer*—W. I. Slichter, New York, N. Y.; *Acting national secretary*—H. H. Henline, New York, N. Y.

The minutes of the board's meeting held August 2, 1932, were approved.

A memorial resolution was adopted in memory of Dr. C. O. Mailloux, a charter member and past-president of the Institute, who died on October 4, 1932. This resolution is published elsewhere in this issue.

A report of a meeting of the board of examiners held September 28, 1932, was presented and approved. Upon the recommendation of the board of examiners, the following actions were taken upon pending applications: 6 applicants were transferred to the grade of Fellow; 6 applicants were elected and 30 were transferred to the grade of Member; 38 applicants were elected to the grade of Associate; 138 Students were enrolled.

The following resolution was adopted:

WHEREAS, death has suddenly removed Colonel Basil C. Battye, D.S.O., A.M., Local Honorary Secretary for India of the American Institute of Electrical Engineers, be it

RESOLVED: That the board of directors at its meeting of October 12, 1932, places this minute on record as an appreciation of the loyal and devoted service which Colonel Battye gave to the Institute as its official representative in India. His thorough understanding of conditions in India, and his able judgment have served as an unfailing guide to our board of examiners through many otherwise perplexing problems.

The resignation of George A. Mills as a vice-president of the Institute, representing the South West District, on account of his removal from that District, was presented; and Stanley Stokes, consulting electrical engineer of the Union Electric Light and Power Company, St. Louis, Mo., and a Fellow of the Institute, was elected vice-president of the Institute for Mr. Mills' unexpired term, ending July 31, 1934.

The following members of the Board of Directors were selected to serve on the national nominating committee for this year: A. B. Cooper, A. E. Knowlton, W. S. Lee, A. C. Stevens, and H. R. Woodrow.

The Institute's representative upon the joint committee of engineers and architects was discharged, report having been made of the completion of the committee's work.

A report was received from Chairman F. B. Jewett of the Institute's committee on Iwadare Foundation, to the effect that the committee had arranged for Dr. Frank J. Sprague, a past-president of the A.I.E.E., to lecture in Japan this fall under the Iwadare Foundation.

Institute representatives were appointed as follows:

On Standards Council, American Standards Association.—A. M. MacCutcheon was reappointed a representative for the 3-year term beginning January 1, 1933, and H. H. Henline and E. B. Paxton were reappointed alternate representatives for the calendar year 1933. H. S. Osborne was designated as the chairman of the Institute's representation on the standards council.

On Engineering Foundation Board.—Past-president C. E. Skinner was reappointed for the 3-year term beginning in February 1933.

On Library Board, United Engineering Trustees, Inc.—W. A. Del Mar was reappointed for the 4-year term beginning in January 1933.

On Board of Trustees, United Engineering Trustees, Inc.—President H. P. Charlesworth was reappointed for the 3-year term beginning in January 1933.

The following actions were taken upon the recommendation of the standards committee:

Approved a revision of Section 4-102 of A.I.E.E. Standard No. 4, "Measurement of Test Voltages in Dielectric Tests," as suggested by the committee on electrical machinery.

Approved a revision, proposed by the committee on electrical machinery, of A.I.E.E. Standard No. 13 on "Transformers, Induction Regulators, and Reactors," and referred it to the sectional committee on transformers being organized under the sponsorship of the electrical standards committee of the American Standards Association.

Adopted a recommendation in favor of a proposed revision of the present A.I.E.E. Standard No. 14, "Instrument Transformers," for reference to the sectional committee on electrical measuring instruments which is being organized under the sponsorship of the electrical standards committee of the A.S.A.

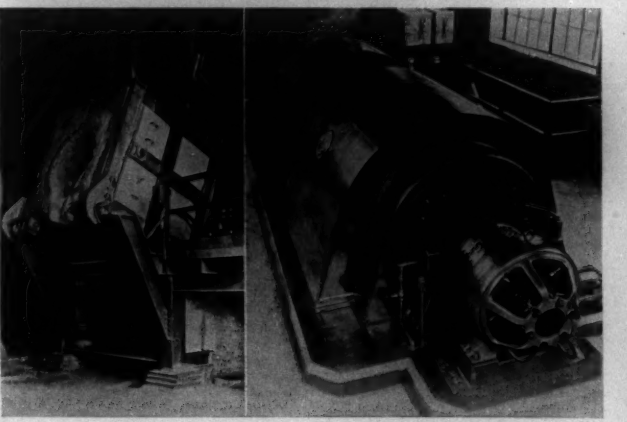
Approved, as a joint sponsor, the revised "Code for Protection Against Lightning" as prepared by the sectional committee on that subject.

Granted permission to the U.S. Department of Commerce to publish the A.I.E.E. standards in the *Encyclopedia for Standards and Specifications*.

Granted permission to the Asociacion de Ingenieros del I.C.A.I. to reprint the Institute standards in the Spanish language.

A resolution was adopted decreasing the number of meetings of the board of directors during the year beginning October 1, 1932, in order to reduce expenditures for traveling expenses; meetings of the executive committee to be substituted at the discretion of the president. In line with this action

A 4-Ton Coreless Induction Furnace



DURING the fall of 1931 a 4-ton coreless furnace capable of melting 40 to 50 tons per day was put in operation in the Chicago district. This is almost double the size of any coreless melting furnace previously installed. The main purpose of the furnace is to melt low carbon stainless steep scrap, also ferro-alloys for addition to larger furnaces, and metal for ingots of high quality tool steel and other alloys. The coreless induction furnace is essentially an air transformer whose primary is a single helical layer of water cooled copper tubing, and whose secondary within the coil is a conducting mass constituting the charge to be melted. Induced currents circulate in the outer part of the charge, and thereby heat it. The furnace, tilted for pouring, is illustrated on the left, and the 1,000-cycle motor generator set is shown on the right. The use of structural steel in the construction of the furnace is more extensive than in any previous installation. Another distinguishing feature of this installation is the carrying of 12,000 amp at 1,000 cycles by means of water cooled tubing interlaced to cut down inductance.

it was voted that the December meeting of the board be omitted and that the next meeting be held in New York, in January, during the Institute's winter convention.

Also because of economic conditions, the board voted to omit the publication of a YEAR BOOK in 1933 and to omit the cash prizes for papers presented in the calendar year 1932, except the District prizes for Branch papers; the certificates for all prizes to be issued as usual.

A budget for the appropriation year of the Institute beginning October 1, 1932, submitted by the finance committee, was adopted with minor revisions.

The board adopted a resolution of congratulation to the local meeting committees upon the excellent results of their efforts in connection with the Middle Eastern District meeting of the Institute, held at Baltimore, October 10–13.

Other subjects were discussed, reference to which may be found in this or future issues of ELECTRICAL ENGINEERING.

District No. 2 Officers Meet at Baltimore

Preceding the first technical session of the Middle Eastern District meeting held at Baltimore, October 10–13, 1932, the executive committee of that district met Monday morning, October 10, with Dr. W. B. Kouwenhoven, district vice-president, presiding. Every one of the 12 sections in the district was represented and the attendance was full, as indicated in the accompanying tabulation, with the exception of the Student Branch counselor member. Extensive routine District business and discussions of matters of policy kept the committee in session all morning, after which the committee adjourned to an informal luncheon from which they went directly to the opening technical session. Present were:

H. P. Charlesworth, President, A.I.E.E. (visitor)
W. B. Kouwenhoven, Vice-president, District No. 2
Geo. S. Diehl, Secretary, District No. 2
H. H. Henline, Acting Nat. Secy., A.I.E.E.
C. E. Skinner, Past-president, A.I.E.E. (visitor)
A. P. Regal, Section Chairman, Akron, Ohio
John Wells, Section Chairman, Baltimore, Md.
L. O. Dorfman, Section Chairman, Cincinnati, Ohio
John M. Smith, Section Chairman, Cleveland, Ohio
W. L. Everitt, Section Delegate, Columbus, Ohio
C. V. Roberts, Section Secretary, Erie, Pa.
N. S. Hibshman, Section Delegate, Lehigh Valley
J. L. MacBurney, Section Secy., Philadelphia, Pa.
Thomas Spooner, Sec. Chairman, Pittsburgh, Pa.
A. P. Bender, Section Chairman, Sharon, Pa.
I. H. Heitkamp, Section Chairman, Toledo, Ohio
T. J. MacKavanagh, Sec. Chmn., Washington

In accordance with the requirement in article VI of the constitution, Prof. A. M. Wilson (A'09–M'18) professor of electrical engineering at the University of Cincinnati (Ohio) was nominated for the office of vice-president of the Institute representing District No. 2 for the 2-year term beginning August 1, 1933. To represent District No. 2 on the national nominating committee, which probably will hold its meeting some time early in December, John Wells (A'27) development engineer for the Western Electric Company, Baltimore, and chairman of the Baltimore Section (1932–33) was appointed and given instructions.

To form, in accordance with section 33 of the by-laws, "A small continuously functioning coordinating committee" Thomas Spooner (F'29) of Pittsburgh, John M. Smith (A'24) of Cleveland, L. O. Dorfman (M'28) of Cincinnati, and T. J. MacKavanagh (M'13) of Washington, D. C., were appointed from the executive committee and Prof. Lewis Fussell (M'22) Professor of electrical engineering of Swarthmore, (Pa.) College representing the student branch counselors, were elected to serve with the district vice-president and secretary.

To serve District No. 2 for the year 1932–33 a District prize award committee was appointed, consisting of Dr. H. L. Curtis (A'21–F'26) Washington, D. C., A. P. Bender (A'18) Sharon, Pa., and Prof. S. S. Seyfert (M'13) Lehigh University, Bethlehem, Pa. Dr. Curtis will serve as chairman of this committee.

Concerning future district meetings for the Middle Eastern District, and their financing, there was considerable discussion. Concerning the matter of finance, the concensus of opinion was to the effect that all sections in the district should bear a reasonably proportionate share of the expense of holding each district meeting, regardless of where it may be held; the group decided to continue the present plan of requesting each section to pay an assessment of $10 plus 10 cents per member in that section as of August 1. The question of a meeting for 1934 was discussed, but no requests for such meeting were voiced and no recommendations were made.

Winter Convention Committee Appointed

The general convention committee in charge of arrangements for the coming annual winter convention of the Institute which is to be held in the Engineering Societies Building, New York, N. Y., January 23–27, 1933, has been appointed by President Charlesworth. Plans for the various events which are to comprise this convention are assuming definite form, a tentative program of technical sessions has been made, and the preparation of papers for these sessions is well under way.

As members of the general convention committee President Charlesworth has appointed the following: *chairman*, E. B. Meyer (F'27) vice-president District 3; J. W. Barker (F'30) member, technical program committee; T. F. Barton (F'30) chairman, New York Section; F. M. Farmer (F'13) member, research, and power transmission and distribution committees; W. H. Harrison (F'31) chairman, technical program committee; L. W. W. Morrow (F'25) Institute representative on Engineers' Council for Professional Development; C. E. Stephens (M'22) director, and chairman, finance committee; H. R. Woodrow (F'23) director, and C. R. Jones (A'16,M'30) secretary District 3.

Ample material is available for the technical sessions, and these include a wide range of subjects in the field of electrical engineering. Special plans are being made for the communication session and these tentatively provide for the presentation of 5 papers on the communication system of railroads. Tentative plans of the committee on education provide for a symposium on post college education. The electrical machinery committee also is making special plans, and these include the holding of an informal session on noise. At some other sessions presentation of manuscripts without publication and without distribution of advance copies is being considered.

Subjects tentatively under consideration for technical sessions are: communication, electric welding, automatic stations, electrical machinery, transportation, education, industrial applications, lightning, electrochemistry and electrometallurgy, instruments and measurements, applications to mining work, protective devices, selected subjects and, research and applied electronics. Detailed plans for the technical sessions, social features, and inspection trips will be announced in future issues of ELECTRICAL ENGINEERING.

Generation Committee Plans New Papers

Capitalizing upon the opportunity presented by the recent Middle Eastern District Meeting held at Baltimore, Md., October 10–13, 1932, Chairman J. R. Baker called a meeting of his committee on power generation on October 12.

To orient the committee, the activities during the past 4 years were reviewed and the papers produced on the general subject of electric power generation were listed in 3 groups according to classification of subject matter: (1) steam-electric production, (2) hydroelectric production, and (3) utilization of sources of power supply by means of interconnection. According to their types these papers were segregated further into such classifications as plant descriptions, analytical discussions, and reports of experimental work. There have been 23 papers on the subject of steam-electric generating plants, 16 concerning hydroelectric practise, and 18 dealing with various phases of interconnection.

Of the 3 subjects mentioned in the foregoing paragraphs 2 were considered to have been fully reported upon to date and to have been adequately described and analyzed for the present: developments in hydroelectric practise, and matters pertaining to interconnection. Recent progress in the field of steam-electric power production was considered to be of timely importance and to be a desirable subject for a paper to be presented in the near future, so as to call attention to profitable lines of design. Possible sources of such a paper were discussed; 2 plants now under construction were considered as exemplifying present trends, one in initial design and the other as a splendid example of rehabilitation.

Electrical testing of welded pressure vessels came up for consideration and specifications were discussed for a suitable paper relating to that subject that might be presented in conjunction with one already on hand concerning the economics of high

pressure and high temperature. The committee gave attention to the difficulty of giving a complete understanding of advances in power generation without elaborating too deeply upon the features of mechanical design. Plans also were made for a paper that would describe the electrical system adopted in a large plant recently placed in operation in which both a 60-cycle and a 25-cycle electric power supply were demanded. Other subjects to be initiated will concern safety devices in electrical operation, automatic turbine control through remote metering, and power control at generating stations. A subcommittee was established to handle a contemplated progress report covering the present biennial period.

Birmingham Section Reorganization Announced

A meeting of the Birmingham Section of the Institute was held on September 30, 1932, for the purpose of discussing future plans and reorganizing the Section. The meeting took place in the Tutwiler Hotel, the reported attendance being 17 Institute members and 1 Student member. F. C. Weiss (M'19) acted as presiding officer.

Following a discussion of various schemes to best serve the Birmingham Section, an organization was formed to carry on the Section's business and maintain a nucleus around which additional activities can be added as the occasions demand. The new chairman is Howard Duryea (A'11) Commonwealth & Southern Corporation, Birmingham, Ala., and the new secretary is H. M. Woodward, (M'29) Southern Bell Tel. & Tel. Company, Birmingham, Ala. The following were named as the executive committee: Prof. F. R. Maxwell (M'30) University of Alabama, Tuscaloosa, Ala., Prof. W. W. Hill (M'24) Alabama Polytechnic Institute, Auburn, Ala., and W. W. Ballew (M'28) Westinghouse Elec. & Mfg. Co., Birmingham, Ala. With the organization of the Birmingham Section, the present list of Institute Sections is made complete.

District No. 8 Officers Meet at San Francisco

With Pacific District Vice-President A. W. Copley in the chair, the executive committee of the Pacific District held its annual meeting at the Engineers' Club in San Francisco September 7, 1932. With the exception of A. P. Hill, secretary of the Los Angeles Section, all members were present; in addition to the chairman were:

C. E. Baugh, secretary, District No. 8.
F. E. Dellinger, chairman, Los Angeles Section.
E. F. Maryatt, chairman, San Francisco Section.
Roy Wilkins, secretary, San Francisco Section.
L. E. Reukema, chairman, District student activities.

As nominee for Institute's vice-president for the 2-year term August 1, 1933–July 31, 1935, representing District No. 8, Prof. R. W. Sorensen (A'07, F'19) professor of electrical engineering at California Institute of Technology, Pasadena, was selected by unanimous vote.

A Review of Foreign Broadcasting Systems

Ten years ago, 6 British radio manufacturers contributed £10,000 each to a common fund with which to commence a system of domestic broadcasting in Great Britain. They formed the British Broadcasting Company, Ltd., which, for 4 years, pioneered broadcasting. In 1926, the company obtained a royal charter and became the British Broadcasting Corporation—known familiarly as the B.B.C.—licensed by the government to transmit broadcast material of every description with only one fundamental restriction: the B.B.C. cannot accept monetary considerations from outside interests in return for broadcasting programs. In other words, it cannot transmit advertising programs for payment; its revenue is derivable solely from a license fee paid by owners of receiving apparatus.

The broadcasting system of Great Britain is almost unique. It is controlled by a board of governors appointed by the government. It operates under a license granted by the postmaster-general, who charges every set-owner 10 shillings per annum for the right to install and operate a receiving station, or in other words, a radio set. From this 10-shilling fee the post office allots a proportion (about 48 per cent) to the B.B.C. as a contribution toward the expenses of broadcasting programs and another portion goes to the national exchequer. There is nothing to insure that the B.B.C. shall receive any contribution at all from the post office license revenue and if the present 48 per cent were stopped or reduced, the B.B.C. might be forced to accept "sponsored programs."

The B.B.C. is a semi-state department as its directorial personnel is appointed by the government and its revenue granted by the postmaster-general almost ex-gratia. Also, the government of the day has first call on any air time and has more than once exercised that right. The B.B.C., as a semi-state department can be criticized in parliament. No fundamental alteration in the constitution of the B.B.C. and the present policy of British broadcasting can be effected until 1937 when the charter expires and comes up for renewal or modification.

Broadcasting is vastly different both on the continent and in the United States, the latter being entirely on a commercial basis. Canada now has decided to remodel its broadcasting system from the American method of commercialization to the British method of centralized control directed to securing highest entertainment value. Government control is also effective in Czechoslovakia, when the Prague station broadcasts some of the most popular programs. Danish broadcasting is governed by the state radio council and financed by the proceeds from license fees.

France has its own method. While there is no monopoly as there is in Great Britain, the majority of the stations are owned by the government through the ministry of posts, telegraphs, and telephones. There are 28 broadcasting stations in that country. A license fee of one franc per year is charged French citizens while foreigners have to pay 10 francs per year.

A broadcasting monopoly is enjoyed by the postal service in Germany while broadcasting is prohibited in Greece, although the government is contemplating creating a monopoly. Monopolistic control is effective also in Hungary where radio is under the control of the postal administration and about 2s. 6d. per year is charged to receivers. Broadcasting is also a monopoly in the Irish Free State and 10s. license fee, as in Great Britain, is charged. Before the end of this year a new high-powered station will be opened in Ireland, whence "sponsored programs" will be transmitted.

The broadcasting situation in Holland is peculiar and almost resolves itself into a war between the non-partisan Association of Listeners, with about 100,000 paying members, the Socialist, and the Catholic broadcasting organizations. There are 2 Dutch stations—Hilversum and Huizen—but only one station can function at a time and the time allotted to each organization is computed upon the basis of the number of members belonging to each. The authority which decides all radio matters is the Radioraad which is presided over by a high government postal official.

—Excerpts from an article appearing in *Industrial Britain* for August 1932, p. 3.

Noble Prize Awarded to Institute Member

The Alfred Noble Prize for 1932 is to be awarded to F. M. Starr (A'30) for his paper "Equivalent Circuits—I." This paper was presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932, and was published in the A.I.E.E. TRANS., v. 51, 1932, p. 287–98. An article based upon this paper was published in ELECTRICAL ENGINEERING for August 1932, p. 555–8. An item regarding Mr. Starr is given in the personal columns of this issue.

This is the second award of the Alfred Noble Prize, the 1931 award having been made to Prof. C. T. Eddy of the Michigan College of Mining and Technology, Houghton, Mich. The prize was established in 1929 and at present consists of an award of $500 from the income of the fund contributed by engineers and others in honor of Alfred Noble, past-president of the American Society of Civil Engineers and of the Western Society of Engineers, and for the purpose of perpetuating his name and achievements. Alfred Noble, one of the most prominent civil engineers active during the 50 years preceding 1914, in addition to his technical achievements was greatly interested in the younger men of the engineering profession.

The award is made to a member of any grade of either the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engi-

neers, or the Western Society of Engineers, for a technical paper of particular merit accepted by the publication committee of any of the foregoing societies for publication, in whole or in abstract, in any of their respective technical publications, provided the author, at the time the paper is accepted in practically its final form, is not over 30 years of age.

The recipient of the prize is selected by a committee of 5, consisting of one representative of each society, the award being based upon papers published by the societies within the 12 months preceding July 15 of each year. The report of the committee is made to the board of direction of the American Society of Civil Engineers at its October meeting, which was held this year at Atlantic City, N. J., October 5–8. The award will be made to Mr. Starr by a representative of the American Society of Civil Engineers at a future meeting of the A.I.E.E.

Last Year's Unemployment Relief to Serve as a Guide for the Future

PLANS for unemployment relief during the coming winter are being made in all sections of the country and must play an important part in the activities of engineers. A review of the work accomplished in various cities during the past year may be of assistance to those groups which are making plans for the coming season, and therefore is attempted in this article. Plans which are being formulated at present by different organizations will be announced soon and will be reported in future issues of ELECTRICAL ENGINEERING.

During the past year engineers in all sections of the country have proved themselves willing and anxious to assist their fellows, with the results that much good was accomplished and distress almost entirely eliminated. The assistance given took many forms, ranging from outright gifts to temporary or more permanent loans, the securing of temporary positions, many of these in "made" work, as well as the finding for many engineers of permanent positions in industry. It is generally felt that the results of last year's efforts warrant being sustained through the coming winter. In general, the needs which are anticipated seem to be not greatly different than those which existed last winter and the maintenance of the scale of the relief given last year should be adequate through the coming year. Too much stress, however, cannot be made of the fact that concerted and active effort is necessary immediately. Some of the novelty which relief workers experienced earlier in the campaign against unemployment has doubtless worn off and those engaged in the coming campaign realize that serious effort must be made.

INSTITUTE SECTION ACTIVITIES

Activities of the Institute providing for unemployment relief have been carried on by the Sections. Following a resolution recommending such action, adopted by the Board of Directors at a meeting held October 23, 1931, Sections of the Institute throughout the country participated in the organization of committees of engineers, usually composed of representatives of all the engineering groups in the community, and cooperating with other local civic relief organizations.

Surveys have been conducted by these Section groups to determine the need for relief and the extent of local opportunities for constructive work or employment, using the aid of engineers who are at present unemployed as far as possible. Funds for loans to deserving unemployed engineers have been collected and administered.

Many valuable data have been collected by the questionnaires which have been sent out by many of the Sections. By this means the number of unemployed has been ascertained quite accurately, together with information on the urgency of the cases, and types of positions for which the individuals are fitted. A survey of the industries in each locality has disclosed many positions which could be filled to the advantage of both employer and employee. Surveys of municipal projects which could be undertaken have been a most important phase of the work. Efforts which for some time have been carried on to reduce the number of working hours both in government bureaus and industries is producing some results, although not as extensive as was originally hoped for.

Educational activities, particularly in the metropolitan areas, have done much to maintain the morale of those unemployed and to prepare them for other positions in industry. This activity, comparatively new, has assumed different forms, but the assistance of established educational institutions usually is secured in formulating courses and securing instructors.

Many of the local committees, although active, have not supplied detailed information regarding their procedures and results, and consequently a full report on these activities cannot be made to other Sections of the Institute. However, in many cases the activities of Institute members have been so closely interwoven with those of other civic groups that no separate report could be given.

Table I—Classification of Placements

On P.E.C.U. payrolls	308
Receiving other relief, such as that given by the Gibson, Bliss, and general public committees in the metropolitan district of New York	960
In permanent engineering jobs	246
Total	1,514

NEW YORK CITY UNEMPLOYMENT ACTIVITIES

The plan developed for unemployment relief in the metropolitan district of New York, N. Y., was carried out during the past winter with considerable success. The details of this plan were described in ELECTRICAL ENGINEERING for March 1932, p. 205–7. The organization formed "The Professional Engineers Committee on Unemployment" is known locally as the "P.E.C.U." and represents the New York Sections of the 4 national societies of civil, mining, mechanical, and electrical engineers. The first meeting of the P.E.C.U. was held October 21, 1931.

In addition to other forms of activities and assistance, the New York sections of these 4 national engineering societies made up a separate fund to take care of overhead expenses of the P.E.C.U. The Institute's New York Section more than filled its quota, and secured a margin to start the coming winter. This fund was secured by donations of $1 from members of the Section.

Up to October 11, 1932 the P.E.C.U. had a total of 2,188 active registrants among unemployed non-members and members of the 4 national societies. In addition to these active registrants, over 500 others had registered but were not regarded as active applicants for relief, as they had registered for educational courses, did not reply to letters, or had later stated that they were interested only in permanent engineering positions, not in relief. Of the 2,188 active registrants, 1,514 placements have been made. These may be divided as shown in Tables I to IV.

TYPE OF WORK SECURED

Of the 1,514 engineers placed by the P.E.C.U., 419 were placed with the Emer-

Table II—Division Among Society Members and Non-Members

Society	Registered	% of Total Registration	Placed	% of Total Placed	% of Registered Placed
Am. Soc. of Civil Engrs.	240	10.9	204	15.2	85.0
Am. Inst. of Metal. & Mining Engrs.	35	1.5	33	2.5	94.3
Am. Soc. of Mech. Engrs.	357	16.2	277	20.7	77.5
Am. Inst. of Elec. Engrs.	212	9.6	173	12.9	81.6
West. Soc. of Engrs.	4	0.3	4	0.3	100.0
Non-Members	1,349	61.5	648	48.4	48.3
	2,197	100.0	1,339	100.0	
Duplicate membership	9		7		
	2,188		1,332		
Men placed more than once			182		
Total			1,514		

Table III—Analysis by Marital Status

Marital Status	Registered		Placed
Single	655		265
Married	1,449		1,039
Widower	33		18
Divorced	29		10
	2,166		1,332
Unaccounted for	22		
		Replacements	182
Totals	2,188		1,514

Table IV—Analysis by Salary Groups

Previous Salary	Registered		Placed
$6,000 or better	130		106
$3,600–$6,000	512		381
$2,400–$3,600	1,028		627
$2,400 and below	496		218
	2,166		1,332
Unaccounted for	22		
		Replacements	182
Totals	2,188		1,514

gency Work Bureau, known as the Gibson committee, mostly in city bureaus, colleges, and universities, and relief work in this district. Men were employed in city departments for surveying, drafting, making mechanical plans and specifications for hospitals, for traffic surveys, as playground and gymnasium instructors, plan examiners for municipal buildings, and truant officers; as assistant professors, draftsmen, general office workers, stock men and laborers in colleges and universities; and for the collection of city relief funds and the carrying on of home relief investigations for other relief organizations.

The City Work and Relief Administration, known as the Bliss committee, took 392 of the men as key men in home organizations, timekeepers, checkers, payroll men, pay masters, and field men engaged by the heads of various city departments, mostly in construction and maintenance work.

In other organizations, 31 were engaged in a topographical survey, 44 for surveying in an outlying county, 64 by the Westchester County Park Commission, mostly for general laboring work, and 10 others in 3 smaller units.

The P.E.C.U. itself employed 60 salary workers on the home office staff for interviewing, registering, classifications, placement, payroll, consultation bureaus, investigations, and soliciting funds. A total of 248 others are paid directly by the P.E.C.U., but are assisting other organizations in a great variety of work.

Permanent engineering positions have been secured for 246 men. Some of these are not strictly engineering activities but may be classed as permanent positions.

Sources of Funds

The amount raised in cash and pledges, the number of contributors, and average amount individually contributed by the membership of the 4 national societies in the metropolitan district of New York are shown in Table V. The canvassing for this money was done in 3 ways: by letters of appeal; by unemployed engineers as canvassers or solicitors, they being paid the relief wage; and by voluntary committees of members of the societies doing personal canvassing. The letters of appeal were 4 in number. The first went to the 13,000 members of the 4 national societies in the metropolitan district of New York. The second, third, and fourth were sent to those who had not replied to the preceding letters, it being necessary to mail but 5,400 copies of the last letter. The engineers were divided into 2 classes: (1) a special group supposed to contain the more affluent members of the profession, to the number of 571; and (2) the remainder of the members. Contributors on the special list to the number of 183 gave $30,526.60, or an average sum of $166.80 each.

Of the total of $109,723.96, about $20,000 was originally in the form of subscriptions or pledge cards, the donor electing to contribute on a monthly or weekly basis over varying periods of time, some as long as 5 months. Experience indicates that only about $1,000, or roughly, 5 per cent of the total number of pledges are in default. In nearly every such case the pledger has lost his job since undertaking his obligation. The total sums obtained to May 15, 1932, are shown in Table VI. The first figure, $107,841.09, shown for that date corresponds to the figure of $109,723.96 shown in other tables as of October 11, 1932.

Also, a loan meets only the momentary emergency.

The P.E.C.U. has been very active in persuading the gas and electric light companies to forebear enforcing routine orders to discontinue their services to destitute engineers. In some instances it has been possible to persuade holders of mortgages to be more lenient in the terms on which they extended or renewed them. Occasionally money has been loaned to pay interest on mortgages.

A legal aid department has been established, whose function has been to give free legal advice to registered unemployed whose circumstances were such that they required such advice. Similarly, an agency has been set up to assist registered unemployed who had developed inventions or processes possibly warranting patents. Assistance also has been given registered men in preparing letters outlining their past experience in a way to interest the prospective employer. This has been supplemented with a mimeographing service to produce multiple copies of such letters.

As regards clothing, the McGraw-Hill Company donated floor space and 2 unemployed engineers were set to work to operate a clothing bureau. On May 14, 1932, 203 men, 61 women, and 58 children had been provided with clothing, contributed largely through the efforts of the Engineering Woman's Club of New York. This clothing has been a godsend to many unemployed men, who, if they had not had

Table V—Analysis of Contributions to Oct. 11, 1932

	No. of Contributors	% of Total	% of Membership in Territory	Total Contributions	% of Total Contributions	Avg.
Civil	787	22.46	22.5	$ 34,547.38	31.4	$43.90
Electrical	1,134	32.40	30.4	22,502.62	20.5	19.84
Mechanical	1,115	31.83	38.3	25,282.96	23	22.67
Mining	265	7.56	8.8	12,222.47	11.2	46.12
Non-Members	202	5.75	...	15,168.53	13.9	75.09
	3,503	100.00	100.0	$109,723.96	100.0	$31.32

Types of Relief Provided

The average relief afforded the individual unemployed engineer through the P.E.C.U. up to May 15, 1932, has been $19.05 per week; this sum has varied somewhat depending upon where the relief was obtained, as shown in Table VII. At that date there had been 73 loans granted in amounts in excess of $15, totaling $3,355, and averaging $45.18 per man. There had been 60 emergency loans granted in amounts less than $15, totaling $248 and averaging $4.13 per man.

These loans were on demand notes without interest. The expectation is that ultimately a considerable percentage of the borrowers will repay them. The funds so collected will be reserved for possible future use.

The relatively small number of loans made and the meager sums of money required surprised those active in the P.E.C.U. Apparently engineers (especially our members) are extremely loath to apply for loans. They much prefer wages from made work or even direct relief from city bureaus.

Table VI—Total Sums Obtained to May 15, 1932

Cash and pledges	$107,841.09
Second-hand clothing, est. value	4,500.00
Unexpended balance of state and federal contributions for U.S. geological survey	11,330.00
Raised separately for administrative purposes to cover such items as postage and telephones	5,247.00
From President Hoover and the Engineers' Club of N. Y. for engineers outside the metropolitan district of N. Y.	5,700.00
Wages paid by semi-public bodies to P.E.C.U. engineers at the instigation of the P.E.C.U.	307,119.00
Total	$441,737.09

Table VII—Average Relief Afforded

For those paid direct through P.E.C.U.'s payroll	$18.82
For those who obtained relief through the Gibson, Bliss, and other relief committees	21.50
For those who got engineering jobs through P.E.C.U. and other sources	32.50

the clothing, in many cases could not have taken the positions which were found for them. The Engineering Woman's Club not only collected and distributed clothing but also initiated and managed a charity bridge party. Some 700 tickets were sold at $2 apiece, the result being that a net contribution of $1,160 was made to the funds of the P.E.C.U.

Another successful activity was that of certifying unemployed engineers to Columbia University so that they could attend classes without academic credit and without expense. A total of 138 men made 564 registrations in 163 different courses for the winter and spring terms.

Another important committee which was recently established is known as the committee on industrial opportunities. This committee endeavors to place engineers outside the profession. It has prepared a list of some 800 industrial concerns which in its judgment could use engineers for cost studies and in other ways where their technical training and mathematical ability would make them more useful than the ordinary layman. This committee continued its work all summer, and has been reinforced by 2 other groups who solicit positions of a permanent nature. Members will greatly assist the P.E.C.U. if they will kindly inform the committee of any positions they may know of that might be filled by a man with engineering training.

Another committee, known as the committee on construction legislation, has been active in Washington and Albany in endeavoring to persuade congressmen and other legislators that the cutting out of construction enterprises from federal, state, and municipal budgets is fallacious economy, results in great increase in unemployment, and is particularly distressing to engineers.

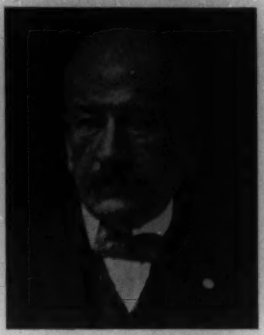
Reviewing the activities of the past winter, the P.E.C.U. feels that its greatest accomplishment has been to convince the semi-public relief agencies of the desirability, from their point of view, of using unemployed engineers in supervising capacities or as key men in directing the 35,000 or 40,000 individuals to whom these agencies have had to give unemployed relief in the form of made work or as direct relief. Extreme care was taken in certifying registrants to these public bodies, to make certain that the candidates sent were qualified for the job in question.

A large part of the work of the registration committee has been to classify all registrants as to their prior experience and their fitness for different types of work. Care along these lines in the early stages of the activities has been rewarded many times over.

Summer Activities Curtailed

Registration of unemployed engineers ceased on April 9, 1932, as it was felt necessary to curtail relief work during the summer months and conserve funds for the coming winter. A small staff was maintained by the P.E.C.U. during the summer months, most of the attention being given to seeking permanent positions for the men, although the most destitute cases were carried throughout the summer. Plans for the coming winter are now being made, and will be announced in future issues of Electrical Engineering.

In Memorium



C. O. MAILLOUX

On the fourth day of October 1932, the American Institute of Electrical Engineers suffered a great loss in the passing on of one of its most revered members, Dr. C. O. Mailloux.

Throughout Dr. Mailloux's career the cause of the Institute has been one of his foremost interests. From the early days of his activity in the organization meeting of May 1884, down through his many years of active service on the standards committee, the Edison Medal committee, the John Fritz Medal board of award; through his work on the United States national committee of the International Electrotechnical Commission, and the presidency of the Commission itself; his years as a director and vice-president of the A.I.E.E., his term as President in 1913–1914, Dr. Mailloux stood and fought for the ideals of the Institute, the maintenance of its high professional standing. Therefore be it

RESOLVED: That the Board of Directors at the meeting of October 12, 1932, record its deep appreciation of these many years of faithful, unselfish work carried on in behalf of the Institute by Dr. Mailloux, its realization of the loss which the Institute has suffered, and its sincerest sympathy to those from whose association he has been taken. And be it further

RESOLVED that this minute be spread on the offical records of the American Institute of Electrical Engineers and that copies be sent to his relatives.

—A.I.E.E. Board of Directors, Oct. 12, 1932

Relief Program in Boston, Mass.

Following independent surveys initiated by the Boston Society of Civil Engineers and the Boston Society of Architects, it was decided toward the end of 1931 that the needs could be met best by cooperation between the professions of engineering and architecture. The Engineering Societies of Boston, composed of 12 member societies, immediately endorsed this plan and appointed an executive committee as well as the following 5 working subcommittees: finance, registration, administration, development, and publicity. As of June 16, 1932, a total of 198 engineers has been given employment, and 121 architects have been placed. A total of 865 engineers and 212 architects had registered on that date as being in search of employment.

The Emergency Planning and Research Bureau, Inc., was formed having 2 divisions, an engineers' division and an architects' division. Each of these divisions administers its own funds, selects the type of work which the men are to do, and keeps its own accounts, all these activities being coordinated through the board of directors of the bureau. The finance committee raises funds from employed members of the profession, these generally contributing one day's pay per month for a period of 20 weeks beginning January 24, 1932. Large organizations are covered by a team captain, and the Society members and other engineers are appealed to by letter. In this manner $79,004.62 was pledged by 2,429 individuals. On June 16, 1932, the period of the pledges not yet being up, $62,024.02 had been received.

Contributions received by the committee were credited to the amount received by the United Boston Unemployment Relief Committee, although the latter had nothing to do with the handling of funds collected by the engineers' and architects' bureau. Contributors to either fund were given the same card and button to avoid the annoyance of any one's being requested to donate to both organizations.

Registration of Applicants

Each applicant registering with the bureau is asked for his exact financial condition in addition to the standard information on education and experience. If his financial condition is critical, the social welfare organization is asked to make a report on the case. This is reviewed by the registration committee, a member of which personally interviews each man. When the committee is satisfied of the need, the applicant is referred to the chairman of the administration committee, who places his name upon the payroll. He is then assigned to work in the drafting room of the bureau.

In determining the work which these men shall do, the development committee has followed 3 general principles:

1. The work shall not conflict with that of any employed engineer and it shall not take work away from any engineer.
2. The work must be of such a nature as to come within the classification of engineering.
3. Not only will the man himself be benefited, but there shall be a possibility that the project will open more work for the engineering profession or that it will be demonstrated that an engineer is the logical man for that type of work.

The projects are of a varied nature, and include:

1. Work for the City of Boston with the architects' division on mapping of city owned property and

blocking of the 1930 census, housing studies, depreciation studies of downtown business sections, and correction of maps for street changes for the planning board.

2. Work in connection with state departments for which there have been no funds available, such as fire protection studies at institutions, surveys in connection with public reservations, smoke investigations, traffic counts, plotting statistical data, surveys of state institutions, gathering of existing data on refrigerating and heating plants at state institutions.

3. Compilation of existing facts relating to New England that can be used for a regional study of this area, such as trends of population, transportation, local government finance, present status of zoning, and use of land in each county.

4. Library research work for committees of various engineering societies.

Employment Bureau

An employment service has been set up within the bureau and operated under state and city laws. No charge is made for services. Two employees of the bureau devote full time to this work, making contacts with organizations which ordinarily do not employ engineers, to "sell" the idea of using engineers. Previous to June 16, 1932, a total of 43 men had been placed in positions having an estimated total income of $10,640. In addition, 74 registered men have gone into work for which there is no income record, the yearly income of all men registered and now employed elsewhere being estimated at $210,000.

The executive director of the engineering division devotes his entire time and is responsible for the work done by the bureau, including the preparation of a weekly report. Office space and equipment have been donated by various organizations. The stationers and makers of blueprints furnish material at a substantial discount. The men work 7 hours per day, 5 days per week, at the rate of $3 per day.

The men receiving assistance are all married, with one or more dependents, the average being 3. For the 130 men on the payroll, the weekly disbursements average $1,600. The payroll expenditure to June 16, 1932 has amounted to $35,977.50, which is 96 per cent of the total expenditures of the bureau. Of the 865 engineers who have registered, 621 or 71.8 per cent, are non-members of any engineering society. The age analysis of registrants is shown in Table VIII.

Table VIII—Applications in Age Groups

Ages	No.	Ages	No.	Ages	No.
18–20	6	31–35	111	46–50	32
21–25	116	36–40	108	51–60	27
26–30	162	41–45	70	61–67	6

Table IX—Subscriptions to Oregon Technical Council Fund

Society	Total Subscriptions Paid In—Sept. 3, 1932
Am. Inst. Mining & Metal. Engrs.	$263.00
Am. Soc. Mech. Engrs.	250.00
Am. Inst. Elec. Engrs.	774.00
Prof. Engrs. of Ore.	280.00
Am. Soc. Civil Engrs.	579.50
U.S. Army Engrs. Unemployment Fund	162.11
Federal Employees Unemployment Fund	439.53
Miscellaneous	5.00
Total	$2,762.14

Results

Favorable publicity has been given the bureau by newspapers, speakers, and by exhibits at conventions and in clubs. The publicity director of one of the public utilities has assisted in this work. It is felt that the development of the welfare plan has resulted in the following benefits:

1. A better understanding among the individual engineering societies comprising the Engineering Societies of Boston.

2. A better understanding of the engineering profession by the general public.

3. The practical example of a well-planned and smoothly operating welfare organization, which has been cited as a model for other groups attempting to solve the relief problem within their ranks.

4. Improved morale of the unemployed engineer, who has been made to feel that he is producing work of value along the lines in which he has been trained, instead of feeling that he is a recipient of charity, giving nothing in return.

5. A closer relationship and a better understanding between the architects and engineers.

Activities in Some Other Cities

Lack of space combined with incomplete reports unfortunately do not permit a comprehensive review of the unemployment work which has been accomplished throughout the country. Much of this work has been of tremendous value assuring employment for needy cases and in sustaining morale. The San Francisco Section of the Institute accumulated a sizable fund which

New Mercury Vapor Turbine to Be Largest in Size

CONSTRUCTION of an unusual power plant to cost some $4,000,000 is being undertaken at Schenectady, N. Y., by the General Electric Company. Perhaps the most unusual feature is that a mercury boiler and turbine will be used, although no little interest is attached to the fact that it is to be the first outdoor steam-electric generating plant. The mercury turbine is rated 20,000 kw, and the station 25,000 kw, as there is also a 5,000-kw non-condensing steam unit. By-product steam will be secured from the mercury condenser; a steam boiler also will be included in the outdoor station. The electric output of the plant will be supplied to the commercial system of the New York Power and Light Corporation, while the steam output will be used in the General Electric works. The mercury vapor will be at a temperature of 958 deg F and 125 lb gage; the steam will be at 760 deg F and 410 lb initial pressure. It is contemplated that the plant will be ready for operation in the spring of 1933.

was used primarily in the form of loans to members or past members of this Section. An interesting procedure was followed by the California division of highways which maintains 2 camps where men are given the privilege of doing part time work on highway improvements in exchange for board and room. The men sent to these camps were distinctly above the average type of laborer in such camps, and were mostly young men. About 500 were cared for by this method.

An organization of unemployed engineers of Philadelphia, Pa., was formed for the purpose of keeping up the morale of their fellow engineers, and assisting employers in securing competent technical help. Approximately 1,000 men have been registered with this group, "The Philadelphia Technical Service Committee," and positions are being found in all branches of industry. (See ELECTRICAL ENGINEERING for July 1932, p. 526.)

As of May 28, 1932, the Engineers' Relief Committee of Pittsburgh, Pa., has collected $6,148.86, unpaid subscriptions amounting to $2,167.16. This has been expended as follows: $2,403.75 for 174 loans to be repaid by 55 individuals, $3,215.76 covering 230 contributions to 46 individuals, $146.10 for operating expenses, leaving a cash balance of $383.25. A total of 209 cases also had been handled at that time, 55 men having been placed in employment and 69 men paid from the committee's funds. Only the most destitute were assisted.

The Oregon Technical Council, Portland, has been disbursing funds for engineers' relief since March 10, 1932. A total of $1,750 has been loaned to 21 applicants. These loans usually run from $5 to $60, no applicant having received over $200. $2,762.14 has been paid by 121 subscribers, about $800 still remaining in the bank on September 3. The sources of the fund classified by societies are shown in Table IX. Plans for the coming year contemplate raising a larger amount from a much larger number of individuals, thus relieving the burden on those subscribing. These subscriptions are not donations, but are loans which will be returned as the loan notes are repaid.

The plan of the Rochester, N. Y., engineering groups last winter was to pool their interest with that of the American Engineering Council's committee on unemployment of western New York, which was organized to assist in promoting work which would bring more employment to engineers in this community. An emergency relief campaign also was organized in Rochester in which the citizens agreed to spend $6,000,000.00 during 3 months for improvements to their homes, factories, or offices. Of particular interest in this section is the "Rochester plan" which was organized by some 15 Rochester industries to assist in relieving unemployment in the State. This plan, quite well known throughout the country, does not become operative until 1933, but should be an important step in curbing future depressions.

Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely. STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

Consumption, Production, Distribution

To the Editor:

The report on the present economic situation rendered by the American Engineering Council (see ELECTRICAL ENGINEERING for June 1932, p. 373–7) seems to me so far beside the facts, so full of obvious inconsistencies and direct contradictions, that, rather than give time to a discussion of the "Report" itself, I shall present hereafter certain specific conclusions I have reached as to the past performance of the existing economic system. Only in this way, I think, is it reasonably probable that any proper deductions as to cause and effect can be drawn.

The conclusions presented are drawn from a very extensive research and energy survey of North America now being conducted by "Technocracy" in the department of industrial engineering in Columbia University. The conclusions are reached through an application to the data of the theory of energy determinants.

The enormous quantity of associated data covering a large number of products over long periods of time and made available through this research proved to be the only source extant from which any direct conclusions could be drawn. Certainly no such data are to be found in any existing treatise or work on economics, nor do the publications of the several industries, our financial institutions, or of the Government, present the required information in logically assimilable form.

A considerable reading in the so-called science of economics has led me to the inevitable conclusion set forth by Veblen, that the foundation of this science rests upon the economic preconceptions of the 18th century, and that it merely attempts to describe our modern economy in these terms. Certainly no "law" of this science has been based upon thoroughgoing analysis of performance in fixed measured units. The "law of supply and demand" is an instance. It appears to me that economics was still in the state of physical science before the birth of Galileo. Nothing has yet been written that attempts to aline the performance of money and price with the performance of the production-distribution-consumption system in terms of a common unit of measure.

Physical energy is fundamental in modern civilization. If its flow ceased (no coal, no oil, no water power, no electric power) our civilization would cease and we would starve to death in 20 days or thereabouts.

The change from man-power at 0.1 hp per unit to mechanical power of unlimited hp per unit began in 1840, and since then has increased at a rate approximating the 8th power of the time. Double the time and our civilization has used $2^8 = 256$ times the power. Between 1830 and 1930 the amount of power used in the United States increased 360 times. At the present time we, on the average, use 150,000 kg-cal of energy per capita per day. Of this only 7 per cent is involved in sustenance (food). The remaining 93 per cent is used in making, distributing, and operating things not sustenance, such as automobiles, railroads, all applications of electric light and power, buildings, and clothing.

Put this measure on any living scale in any part of the world at any time, and much may be learned about the economy of that place and time. Previous to 1840 in all known civilizations, and in China today, the rate of energy dissipation did, and does not, exceed 2,000 kg-cal per capita per day. The implication as to social change and all its concomitants is obvious and significant. Mark you, this change from all of the past has taken place in not quite a century! Observe that, in spite of our vaulting assumptions, on this scale, our living "standard" in relation to our energy reserves is the lowest of any other people in the world!

At this present rate of consumption of energy all our available energy resources will have been used in a century (approximately). If the rate continues to increase as the 8th power of the time, then in 50 years from now, or by 1980, the rate of consumption of energy per capita will be 6,760,000 kg-cal per day. In such an impossible case our entire energy reserves of coal and oil would be used up at that time and all available water power would be entirely insufficient.

It matters not a rap what men think, wish, or desire. We are face to face with a law of nature. The law of conservation of energy has a perfectly definite social implication, and, as a corollary to that, a perfectly definite political implication! It follows that Malthius' law requires restatement in terms of energy.

The average production of all goods has increased since 1840 as the 3rd power (cube) of the time. Since 1890 production as a whole in 1928 had tripled. Some products have increased at much greater rates. Steel production has increased as the 6th power of the time. The continuation of such rates of growth is physically impossible. If the maximum rate of growth in coal production had maintained for 50 years, it would require that the whole earth be a solid ball of coal!

Meanwhile the man-hours used per unit of production has decreased at similar rates. In steel, the rate of decrease has been as the inverse 4th power of the time, in automobiles even greater. In pig-iron production one man-hour does today what 650 man-hours accomplished 100 years ago. In agriculture it requires but 1/3,000 of the man-hours per unit of product required in 1840. In incandescent lamp manufacture one man-hour accomplishes as much as 9,000 man-hours accomplished only so short a time past as 1914! One can go on indefinitely marshaling such facts. The ratio for the whole since 1840 is not far from 1/3,000.

The rate of decrease in man-hours as a

whole is greater than the rate of increase in production, and since 1918 the rate of decrease in man-hours has been approximately the same as the rate of increase in power efficiency of production. We are now substituting kilowatthours for man-hours on a parity basis—1,500,000 ft-lbs per 8 hours = 1 man.

If the rate of decrease in man-hours maintains for 50 years, there will be 20,000,000 unemployed in this country. At the peak of production in 1928 there were nearly 3,000,000 unemployed workers—an amazing fact when you first run into it. If the whole production plant were put to work at full capacity today, there would be about 6,000,000 unemployed workers.

Observe that, in spite of our technical supremacy, the energy efficiency of our civilization grows less at an accelerated rate! Deterioration of quality under the stimulus of competitive "cost" and its concomitant hastened obsolescence through use—in other words, waste—indicates one reason for the wide departure between the rates of increase in energy flow and increase in production, even after deducting the rate of substitution of kilowatthours for man-hours.

The above 3 fundamental facts, (a) the important place of physical energy in our civilization, (b) the growth rates of production which cannot maintain, and (c) the fact that the decrement in man-hours exceeds the growth of production, form the only proper basis for discussion of the present situation or future possibilities. The facts given are not wild guesses. They are a few resulting from careful analysis of much available data that has been checked several ways, and submitted to criticism.

Now to another matter. The industrial debt of this country—bonds, mortgages, bank loans, and all other interest-bearing amortized securities—totals approximately 218 billions. Taxes and obsolescence included, the fixed charges on this debt is 34 billions a year—practically half the national income of 1928! Since 1840 this debt has increased as the 4th power of the time. In other words, we owed in total 16 times as much in 1930 as we owed in 1895. The Government had in issue (June 30, 1931) about 6 billion certificates of debt in the form of demand notes called paper money. Add this to the 218 billions to get a grand total of 224 billions of debt based on 5 billions of gold, or roughly speaking, our money assets have to our liabilities the ratio of 1/50 or 2 cents on the dollar! The war debts are mere pocket change. What would be said of a manufacturing concern in such a financial position? What action on the part of the creditors would naturally follow?

Note that population has been increasing as the square of the time. Therefore the ratio of debt to population increases as $t^4/t^2 = t^2$, or as the square of the time. In 1930 each one of us on the average owed 4 times as much as we owned in 1895. If you think this cannot be correct, look up the data yourself.

Note also that while the debt increases as the 4th power of the time, production increases as the 3rd power of the time. It follows that the debt, which must be supported by the sale of produced goods, increases faster than the production of these goods. In other words, the goods are "put in hock" faster than they can be produced! How long, and by what kind of financial legerdemain, can such a proceeding be maintained?

Now in the light of such facts, consider the economic and financial promulgations issuing from the Hague, from Geneva, from Lausanne, and from Washington! Finally, examine the "reports" on the economic situation produced by American Engineering Council!

Indeed, it is true that "our bankers are debt merchants and economics has become the pathology of debt." Price and production have little relationship now, and ere long will have none. The obvious conclusion is that a production-distribution system, energy operated, cannot be controlled by price, and it is footless to try. Certainly our experience of the past century should show us how footless the attempt has been.

The machine is an agent of liberation. Each of our 35,000,000 workers now uses 3,000 energetic slaves in the form of 300 mechanical hp, each horsepower being the equivalent in work done to 10 human slaves. The machine as a whole actually requires but 2 (not 4) 8-hour days per week from each worker. Why should he do more when, as Russell says, "the morality of work is the morality of slaves."

Obviously each worker must have adequate purchasing power, even if he works but 660 hours or less a year. Well, why not give it to him. But if the facts set down above are fairly correct it is quite evident this purchasing power cannot be in terms of "price." The ingrained concept of price stands in the way of a clear comprehension of the economics of an energy system, quite as the ingrained Euclidian concept of the straight line inhibits a clear comprehension of a non-Euclidian space. Evidently the unit of labor or work—the man-hour—is not the proper measure of economic values for we are doing away with the man-hour.

Well, what is the answer? Certainly it is not contained in the report of the Engineering Council for one!

Very truly yours,
BASSETT JONES (F'30)
(101 Park Ave.,
New York, N. Y.)

Author's Note: The time rates given in the above are illustrative. The actual functions fitting the data are not simple functions of the time, but do not involve higher powers of the time than those given. Thus, I have expressed population growth as the square of the time t^2. That is sufficiently accurate for the present purpose. The actual population growth function for the United States is given by Pritchett, $p = 9{,}064{,}900 - 6281430t + 842377t^3 + 19{,}829{,}500 \log t$. For production of goods, the functions are oscillating, the power of the time given being the highest power in the equation of the axis of oscillation.

European Broadcasting Stations

To the Editor:

In connection with the short notice on "European Broadcasting Stations," appearing in ELECTRICAL ENGINEERING for September 1932, p. 666, it may interest your readers to get a few data about the equipment used to an increasing degree in European broadcasting stations.

Late in 1928 the Marconi Company in London, England, decided to install for the new Chelmsford station a high-voltage mercury arc rectifier for feeding the amplifiers, for which purposes otherwise thermionic valve rectifiers had been used, and which give satisfactory service but unfortunately have only a very limited life, thus enormously increasing the operating costs of such stations. With a mercury arc rectifier no such difficulty could be expected and in fact the equipment in Chelmsford operated with entire satisfaction since its first starting to operate in September 1929. This rectifier was designed for an output of 400 kw at d-c voltages of 9,000, 10,000, and 12,000 volts.

Based on these favorable results, the Marconi Company has later installed a number of similar rectifiers in the stations built for Warsaw, Poland (1,000 kw, 15,000 volts direct current), Muenster, Switzerland (270 kw, 12,000 volts) and Athlone, Ireland (460 kw, 13,000 volts), this latter station having first been opened for broadcasting the features of the Eucharistic Congress held in Dublin in June 1932. The German post administration followed this example and so far equipped 5 stations with high voltage rectifiers ranging from 360 to 1,170 kw and 12,000 to 13,000 volts direct current. Other equipments of this nature will soon be put into operation in Torino, Italy, and some other European stations.

This development, accomplished in the short period of 4 years, shows that mercury arc rectifiers as designed for this special purpose are bound to replace successfully thermionic valve rectifiers with their limited life period, and shows that they have already secured a firm place in modern radio station equipment.

Very truly yours,
PAUL R. SIDLER (A'31)
(New York Representative, 19 Rector St., New York, N. Y., of Brown, Boveri and Co., Baden, Switzerland)

Engineering and Human Happiness

To the Editor:

Many of your contributors and correspondents on the subject "Engineering and Human Happiness" recognize in some measure that "man's life consisteth not in the abundance of the things which he possesseth," and that the fundamental condition for individual happiness is an inward or spiritual state characterized by peace of mind and love for one's fellow men. As to what power can create that fundamental condition, no answer is nearer the truth than that of Doctor Pupin in your March issue. (See ELECTRICAL ENGINEERING, March 1932, p. 156–7.)

. . . Given a proper spiritual foundation, true happiness can exist with the minimum of physical necessities or even without them. Engineering as a factor in human happiness seems therefore to be mainly dependent upon the spiritual state of the individual and of society as a whole. Only when man is inwardly prepared for a right use of the gifts of science will the world be safe for engineering progress.

Very truly yours,
C. KENT DUFF (A'28)
(University of Toronto, Toronto, Ont., Canada)

"Class O" Insulating Materials

To the Editor:

The A.I.E.E. standards committee in 1922 provided an additional class of insulating material, namely, "Class O—Cotton, silk, paper, and similar materials when neither impregnated nor immersed in oil."

The committee, possibly influenced by the business depression of 1921, acted in response to a demand for cheaper electrical apparatus. We are again in the midst of a far more serious business depression, and we now have abundant time to contemplate past history. Can we say that we were justified in abandoning the funda-

mental principles upon which dependable insulating materials are based? Does it pay to ignore the superior qualities of impregnated absorbent materials saturated with a suitable substance that replaces the residual moisture and air between its fibers—entirely covers its fibers and renders them adherent to each other and to the conductors—a substance that will not flow or evaporate during the operating service of the machines regardless of overloads or prolonged action of heat?

Why not repeal the 1922 amendment ("Class O" insulation) and while we are about it, omit the words "organic" and "inorganic" wherever mentioned, as we depend upon the useful blending together of all components to make one solid homogeneous winding structure.

In conclusion, may I say that enameled wire is in a class by itself, the most economical wire to make and to use. We don't have to impregnate the enamel coverings, and we could not if we would. We have now available ready-made, solventless, dry, and transparent varnish films (cellulose acetate films) to use as layer insulation for enameled wires; a combination that effectively eliminates varnish tanks and vacuum impregnators in magnet coil production thereby offering another argument for the elimination of "Class O" insulating materials from the A.I.E.E. standards.

Very truly yours,
H. W. TURNER (A'03)
18 Troy Place, Schenectady, N. Y.)

Engineering Foundation

Selecting an Engineering Career

"Engineering: A Career—A Culture" is the title of a pamphlet having as its aim the assisting of young men, their parents, and teachers in high schools and preparatory schools, to answer the all-important question: Should the vocation of engineering be selected as an individual's career? Reliable information for answering this question is needed; romantic stories or enticing propaganda will not do.

The information presented in this pamphlet has been compiled by the educational research committee of the Engineering Foundation, in cooperation with the societies which its members individually represent, namely: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Chemical Engineers, and the Society for the Promotion of Engineering Education.

Following a general chapter upon engineering requirements and opportunities, chapters are devoted to the specific branches of engineering, namely: civil, mining, metallurgical, mechanical, electrical, and chemical engineering. Chapters also are included upon the preparation for engineering, and another upon the earnings of engineers. The purpose in preparing this pamphlet has been to provide as helpful vocational guidance as practicable for engineering as a whole and not for any particular group.

In the pages of this pamphlet much is told about what engineers do, and what qualities of mind and character a youth should have to become an engineer. There is information upon the schooling that the boy should have, and upon the engineering colleges; also upon the training after college is ended and professional work is started. Some idea of the nature of the pamphlet may be gained from the following excerpts taken from the chapter on electrical engineering:

"Electrical engineers must possess mathematical abilities even greater than those necessary to other engineers, for the thing with which they deal, electricity, is energy without material embodiment, and it can be treated only as a mathematical formula. Elsewhere we have pointed out the qualities of imagination required of civil, mechanical, and chemical engineers, who deal primarily with material forces and their relations. The electrical engineer's mathematical analysis of energy and of its applications leads him into a realm of almost metaphysical speculation. . . . Multiplex telephone and telegraph systems for carrying numerous messages simultaneously over the same wires, long distance cables where hundreds of circuits within a single sheath must be prevented from interfering with one another, and the distance effect from the extremely high tension power lines which cover the country, all present problems solved only after the most exacting mathematical analysis. . . .

"Within the corporations of this (electrical) industry most electrical engineers find their careers. From the very nature of the business, large groups have become the rule. Telephone, telegraph, radio, and power transmission imply the connection of many points into systems with interests and administration in common. Growth, too, has been so closely dependent on continued active research that the economy of cooperation in this activity also has aided in the formation of large corporations."

Following also is an excerpt from the chapter on preparation for engineering:

"Engineering is essentially a scientific pursuit founded upon mathematics and natural sciences. . . .You should be prepared to analyze ideas by the logical reasoning of science and with the accuracy of mathematics. . . . The surest indication of possession of the requisite mental ability is your demonstration of it in school. If you have been consistently in the upper half of your classes, or preferable in the upper third, it is probably that you do. . . . You should clearly differentiate between the man who builds things with his own hands (a mechanic) and the professional engineer who plans the things the mechanic builds. The engineer should cultivate his capacity to visualize the intended result of his plan, to see with his mind's eye the things he plans in 3 dimensions as if they were already built."

The pamphlet will be revised as frequently as found desirable and made available to persons in all parts of the country year after year. It is being made available through the local sections of the national engineering societies, the colleges and their alumni organizations, and the Society for the Promotion of Engineering Education. Copies can be obtained also from The Engineering Foundation at 29 West 39th St., New York, N. Y. In lots of 50 or multiples of 50, the price is $10 per 100 copies. For single copies and for lots less than 50, the price is 15 cents per copy. Orders may be sent at any time; 10 per cent discount is allowed for quantity orders with cash before December 31, 1932. Remittances should be made payable to The Engineering Foundation.

Standards

Revision of A.I.E.E. Standard No. 4

The standard for "Measurement of Test Voltages in Dielectric Tests," No. 4 in the A.I.E.E. series, has been revised through action of the standards committee on October 11, which action was confirmed by the Institute's board of directors October 12, 1932. The revision concerns paragraph 4–102, the first 6 lines of that paragraph to be revised to read:

"Impedance of Testing Transformers.—For accurate tests, the impedance of the testing transformer should be not greater than 20 per cent based on voltage and current at which the transformer is operated for any test."

Those having Standard No. 4 may obtain an insertion slip covering this change by writing to the standards committee at A.I.E.E. headquarters.

Proposed Test Code for Synchronous Machines

A proposed "Test Code for Synchronous Machines" was submitted by the Institute's electrical machinery committee to the Institute's standards committee at its meeting of October 11, 1932. Publication of this code, the second in the series originally proposed by the standards committee, was recommended to the board of directors and approved by that body on October 12. The work of publication will get under way at once and a later notice of availability will appear as soon as the date of issue is known. The first code, "Transformer Test Code," has been out for comment since October 1931. There is no charge for copies. Address the standards committee at A.I.E.E. headquarters.

Lightning Protection Code Is Revised

By the action of the Standards Committee on October 11, 1932, later confirmed by the board of directors, the revision of the "Code for Protection Against Lightning" as submitted by the sectional committee

under the chairmanship of Dr. M. G. Lloyd was approved. The original code, developed under the joint sponsorship of the Bureau of Standards and the Institute, was approved by the American Standards Association in April 1929, and was issued as publication No. 92 of the Bureau of Standards. The present revision concerns parts 1 and 2 of the code covering protection of persons and protection of buildings and miscellaneous property. The revised code now will go to the American Standards Association for approval, as recommended by both sponsors, and a new edition eventually will be issued by the Bureau of Standards of the U. S. Department of Commerce.

Wires and Cables

The 3 standards for wires and cables that were approved by the American Standards Association on May 21, 1931: (1) "American Standard Definitions and General Standards for Wires and Cables" (Revised A.I.E.E. No. 30); (2) "American Tentative Standard Specifications for Weatherproof Wires and Cables" (A.I.E.E. No. 72); and (3) "American Tentative Standard Specifications for Heat Resisting Wires and Cables" (A.I.E.E. No. 73) now are available in pamphlet form. Copies may be obtained through A.I.E.E. headquarters. No. 30 is 30¢ per copy and Nos. 72 and 73, issued as one pamphlet, is 20¢ per copy. A discount of 50 per cent on single copies is allowed to A.I.E.E. members. For a detailed statement relative to these pamphlets, see the August 1932 issue of ELECTRICAL ENGINEERING, p. 599.

Personal

M. S. SLOAN (A'07, F'30) from 1928 through 1931 president of the New York Edison and affiliated companies, recently was appointed by the United States Chamber of Commerce as chairman of its committee on federal expenditures.

E. W. JUDY (A'26) operating manager of the Duquesne Light Company, Pittsburgh, Pa., recently became a vice-president of the Pennsylvania Electric Association, an organization with headquarters at Harrisburg, Pa.

C. E. LAKIN (A'25, M'30) who has been serving the National Electric Power Company, New York, N. Y., as electrical engineer now has removed to Greenville, Ohio, to become president of the Greenville Electric Light and Power Company.

J. H. SERVICE (A'22, M'30) who has been professor of physics and mathematics at Henderson College, Arkadelphia, Ark., left that position the latter part of September 1932 to become instructor in mathematics and physics at the Michigan College of Mining and Technology, Houghton, Mich.

CALVIN W. RICE (A'97, F'12) national secretary of The American Society of Mechanical Engineers, New York, N. Y., has been appointed a member of the National Research Council on the division of engineering and industrial research for a term of 3 years beginning July 1, 1932.

L. P. MORRIS (A'30) previously special research assistant on the electrical engineering staff of the University of Illinois, (Urbana) recently joined the television engineering department of the U.S. Radio and Television Corporation at Marion, Ind., where he will take up residence.

A. H. MCLEAN (A'21) deputy city electrical inspector of Portland, Ore., will head the Northwest Section of the International Association of Electrical Inspectors as its president for the ensuing year, according to reports from that organization's convention held at Wenatchee, Wash., September 6–8, 1932.

A. S. BROWN (M'30) formerly in responsible charge of all electrical engineering activities for the Federal Telegraph Company, Palo Alto, Calif., recently became associated with the Butte Electric & Manufacturing Company, San Francisco, as its manager. Mr. Brown was born July 1, 1889, in Minneapolis, Minn., received from Montana State College in 1910 the degree of Bachelor of Science in Electrical Engineering, and in 1915 the degree of Electrical Engineer. Before joining the Federal organization November 1928, he had had 7 years of electrical and radio experience with the United States Navy in positions of increasing importance, including service as radio engineer for the U.S. Navy at Mare Island, Calif., Cavite, P. I., Peking, China, and at the Naval Research Laboratory, Washington, D. C.

R. H. MARVIN (A'04, M'29) since June 1926 Engineering Foundation's "Research Fellow in Electrical Engineering" at the Johns Hopkins University, Baltimore, Md., recently became laboratory engineer for the Doble Engineering Company with headquarters at Medford Hillside, Mass. Doctor Marvin was born in Brooklyn, N. Y., October 27, 1879; received his M.E. degree in 1903 from Stevens Institute of Technology, Hoboken, N. J., his M.S. degree in electrical engineering in 1914 from Union College, Schenectady, N. Y., his Doctor of Philosophy from Johns Hopkins University in 1928. Prior to his work at Johns Hopkins he was successively: in the laboratory of the General Electric Lamp Works, Harrison, N. J. (1903–5); test department of the General Electric Company, Schenectady, N. Y. (1905–6); protective apparatus laboratory General Electric Company, Schenectady, N. Y., associated with the development of lightning protective devices and investigation of transmission system disturbances (1906–14); electrical engineer for The R. Thomas & Company, East Liverpool, Ohio, in charge of design and testing of high voltage insulators and line material (1914–18 and 1919–25); and first lieutenant, radio development department, Signal Corps, United States Army (1918–19).

STANLEY STOKES (A'16, M'21, F'29) consulting electrical engineer for the Union Electric Light & Power Company, St. Louis, Mo., was made a vice-president of the Institute representing the South West District (No. 7) by action of the Institute's board of directors, October 12, 1932. Mr. Stokes was appointed to serve until July 31, 1934, filling the unexpired term of G. A. Mills, formerly of Dallas, Texas, but recently removed to Lansing, Mich. Mr. Stokes was born in Columbia, Mo., February 19, 1890; started to school in Cambridge, Mass., while his father was doing graduate work at Harvard University. Continuing through the customary grade schools, he subsequently went to Kirksville (Mo.) State Teachers' College, then attended and subsequently (1912) graduated from the University of Missouri, with the degree of Electrical Engineer representing an additional year's work. In 1910 and 1911 during summer vacations he was with the Telluride Power Company, Utah, on telephone reconstruction work. During this period he received through the Telluride Association a scholarship at Cornell University of which he was unable to take advantage because of financial reasons. During the academic year 1911–12 he was student assistant in physics at the University of Missouri. Since 1912 Mr. Stokes has been associated continuously with his present or affiliated companies: 1912–14 with the Mississippi River Power Distributing Company as material clerk, estimator, and handling sundry other details incident to substation construction in connection with the Keokuk development; 1914–15, with the Electric Company of Missouri on cost analysis, rate schedule, and other such work, acting as assistant to the vice-president; 1915–16, sales engineer for the Electric Company of Missouri; 1916–18, superintendent of the Jefferson (Mo.) division of the Union Electric Light and Power Company in charge of transmission and distribution construction, and the conversion and interconnection of small local plants; 1918–25, manager of the outlying plant division of this company, serving also during this interval as vice-president and

STANLEY STOKES

general manager of the Commercial Telephone Company operating in Franklin County, Mo.; 1925–29, assistant vice-president in charge of electrical engineering and power supervision, in charge of construction of major transmission lines, and responsible to a large degree for important work in connection with the further development of the Keokuk hydroelectric plant and the complete layout of the Cahokia steam-electric generating plant, as well as the interconnection of these plants. Mr. Stokes' activities have included participation in the affairs of the St. Louis Section, for which he has served as secretary and also as chairman of the program committee. His technical writings include "Hinged Wooden Arms Used on Osage-Rivermines Line," published in ELECTRICAL ENGINEERING for February 1932.

J. W. BARKER

R. T. HENRY

D. W. TAYLOR

R. T. HENRY (A'24, M'29) who now is electrical engineer in charge of design for the Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y., has been chosen as chairman of the Institute's technical committee on protective devices for the ensuing year. Mr. Henry was born at Stronghurst, Ill., and acquired his preliminary education in the Niagara Falls high school graduating in 1907. He then attended the General Electric engineering school at Lynn, Mass., for one year and subsequently attended a summer session at the University of Michigan. In 1908 he engaged with the General Electric Company, at Lynn, as draftsman, a year later to join the Niagara Falls Hydraulic Power and Manufacturing Company, Niagara Falls, N. Y., in like capacity. In 1912 he became assistant electrical engineer of the Hooker Electrochemical Company, Niagara Falls, N. Y., where he was in charge of electrical construction. The next year he became designing draftsman of the Edison Illuminating Company, of Detroit, Mich., and in 1914 joined the Niagara Electric Service Corporation, Niagara Falls, N. Y., as assistant superintendent. Between 1918 and 1929 he was assistant electrical engineer of the Niagara Falls Power Company, the work involving supervision of the design and construction of additions to the generating stations at Niagara Falls, including 3 32,500-kva units and 3 65,000-kva units, together with the high tension and low tension switching stations, transmission lines, and underground cable systems. Since 1929 Mr. Henry has been electrical engineer in charge of design for the Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y., this position really being a continuation of the previous one. Outstanding among the many features which this work has involved is the introduction of the small unit type distribution substation. Mr. Henry is a member of the National Electric Light Association, having been a member of its electrical apparatus committee and chairman of its protective equipment committee. He is a member of the joint committee of the N.E.L.A., A.E.I.C., and N.E.M.A. on oil circuit breakers. He was chairman of the Niagara Frontier Section of the A.I.E.E. for the year following August 1, 1929, and since 1931 has been a member of the Institute's committee on protective devices, of which he is now chairman. Through holding this office he automatically becomes a member of the Institute's technical program committee.

J. W. BARKER (M'26, F'30) dean of the engineering faculty at Columbia University, New York, N. Y., since early in 1930, has been elected president of the Illuminating Engineering Society for the year beginning October 1, 1932. Dean Barker was born June 17, 1891, at Lawrence, Mass. He pursued his education to graduation from Massachusetts Institute of Technology, Cambridge, in 1916 with the degree of Bachelor of Science, subsequently taking graduate work (1924–25) that led to his receiving from the same institution in 1925 the degree of Master of Science. After his graduation in 1916 Dean Barker went as a second lieutenant into the coast artillery of the permanent establishment of the United States Army, and was connected with the development of scientific methods in that service. He was a major in heavy artillery in the American Expeditionary Forces and, after the cessation of hostilities in 1918, served various commissions in France, Germany, and the United States. After his return to the United States he continued in the army as a high ranking captain in the Coast Artillery Corps, where he worked on important projects for sound ranging by electric methods. In September 1925, he resigned from the army to accept appointment as an associate professor of electrical engineering at M.I.T., in which capacity he served until 1929. During the academic year 1929–30 Dean Barker was professor of electrical engineering, head of that department, and director of the electrical engineering curriculum at Lehigh University, Bethlehem, Pa. In addition to his activities in the Illuminating Engineering Society he is a member of The American Society of Mechanical Engineers, the American Society of Civil Engineers, and the Society for the Promotion of Engineering Education. In Institute affairs Dean Barker's activities have included membership on the committee on production and application of light (1929–32); committee on education (1930–32); and technical program committee (1932–33).

D. W. TAYLOR (A'17, M'28) assistant electrical engineer of United Engineers and Constructors, Inc., Newark, N. J., has been reelected chairman of the Institute's technical committee on automatic stations for the current year. Mr. Taylor's birthplace was Cedar Rapids, Iowa. He attended high school in New York, N. Y., and received his E.E. degree from Columbia University. In 1916 he joined the electrical engineering department of the Public Service Electric Company, Newark, N. J., as cadet engineer. In 1918 he became engineering assistant, working principally on general substation design, system protection, and inductive coordination. As assistant engineer in the electrical engineering department of the Public Service Production Company between 1922 and 1925, he was in charge of relay protection for the system of the Public Service Electric Company. During this same period he also was division engineer in charge of the electrical engineering work for Hudson and Bergen divisions of the Public Service Electric Company. From 1915 to 1927 he was assistant electrical engineer, in charge of electrical design for the central division of the company. In 1927 he became assistant executive head of the electrical engineering department, checking all electrical estimates and supervising all electrical designs. Mr. Taylor was for 2 years a member of the relay subcommittee of the apparatus committee of the N.E.L.A., and was one of the editors of the N.E.-L.A. Relay Handbook, writing the section on d-c protection.

W. C. KALB (A'12, M'15) since 1928 with the carbon sales division of the National Carbon Company, Inc., Cleveland, Ohio, has been appointed chairman of the Institute's technical committee on electrochemistry and electrophysics for the current year. Mr. Kalb was born at Arcadia, Ohio, and in 1904 was graduated from Ohio State University at Columbus, Ohio, with the degree of M.E. in E.E. After 3 years as mechanical engineer with The Columbus Pneumatic Tool Company, Columbus, Ohio, and a brief period of construction work with the Jeffrey Manufacturing Company, also located at Columbus, he engaged with the National Carbon Company and was placed in charge of its experimental laboratory for brush testing and development. In 1910 he left the National Carbon Company to become superintendent of The Dunlap Engineering Company, at first taking charge of production work and later supervising the sales department. In 1919 he became associated with the Corliss Carbon Com-

pany, and as general manager, continued with that company until it was purchased by the National Carbon Company, Inc. Mr. Kalb's present work there is in the advertising and technical publicity activities. His work on the Institute's committees has been continuous since 1929, when he was made a member of the committee on the production and application of light, and since 1931 he has served on the committee on electrochemistry and electrometallurgy, of which he now has become the chairman. He of course serves automatically also upon the technical program committee of the Institute, of which all technical committee chairmen become an integral part.

W. C. KALB

W. L. EMMET (A'93, M'94, Member for Life and past-vice-president) consulting engineer for the General Electric Company, Schenectady, N. Y., recently was the recipient of one of the John Scott Medal awards, administered by the Board of City Trusts, Philadelphia, Pa. Doctor Emmet, who already is the holder of over a hundred patents on electrical and kindred apparatus, received this award for his invention of the mercury vapor boiler and its practical application for power purposes. These awards, made annually from a fund established in 1816 by John Scott, a chemist of Edinburgh, Scotland, carry with them besides the medal, a certificate of achievement, and $1,000 in cash. Born at Pelham, N. Y., Doctor Emmet was graduated from the United States Naval Academy at Annapolis in 1881, serving as a cadet midshipman until 1883 aboard the U. S. S. "Essex." In 1887 he joined the Sprague Electric Company, then coping with electric railroad development in various sections throughout the country, and in 1889 was sent to Pittsburgh to superintend one of the largest electric railroad operations of the time. In 1890 he went with the Westinghouse Electric and Manufacturing Company, but only for a short time; he then removed to Buffalo, N. Y., to become electrical engineer for the Buffalo Railroad Company, a position which he again left almost immediately to join the Edison General Electric Company, then just formed, as its district engineer. In 1892 he was transferred to the company's New York office where he started as engineer in charge of the foreign department. In 1898 he re-entered the Navy as junior lieutenant, serving as navigator on the U. S. S. "Justin" during the Spanish War period. In 1900 he started his work of developing the Curtis Steam turbine, the first installation of which at Newport, R. I., proved his great success in this undertaking. Besides the Edison Medal which was awarded him in 1919 for his "invention and development of electrical apparatus and prime-movers," Doctor Emmet has been the recipient of the Franklin Institute's Elliott Cresson Medal "for discovery or original research adding to the sum of human knowledge irrespective of commercial value, of leading and practical utilization," and the Gold Medal of The American Society of Mechanical Engineers, awarded for "distinguished service in engineering and science." He is a member of the American Philosophical Society, the Society of Naval Architects and Marine Engineers, the Naval Consulting Board of the United States, the National Academy of Sciences, and The American Society of Mechanical Engineers.

R. D. MERSHON (A'95, F'12, and past-president) recently had conferred upon him, for valuable service rendered the cause of national defense, honorary life membership in the Reserve Officers Association of the United States. The ceremony took place at the annual convention of that association. Mr. Mershon's memberships in technical and scientific organizations include the U.S. national committee of the International Electrotechnical Commission, the Inventors Guild (past-president) the American Society of Civil Engineers, the American Electrochemical Society, the Franklin Institute of the State of Pennsylvania, the Canadian Society of Civil Engineers, The American Society of Mechanical Engineers, the American Association for the Advancement of Science, the British Institution of Electrical Engineers, the Société Internationale des Électriciens, the University Club, Engineers' Club, and Lawyers' Club, of New York, and the St. James Club, of Montreal.

A. H. BABCOCK (A'04, M'06, F'12) past vice-president of the Institute (1918–19) and for some time consulting electrical engineer of the Southern Pacific (railroad) Company with offices at San Francisco, Calif., retired from office September 1, 1932, after 30 years of continuous service with that company. Mr. Babcock was born at Buffalo, N. Y., August 12, 1865. In the course of his technical training he attended both the University of California, Berkeley, and Lehigh University, Bethlehem, Pa. From November 1891 until July 1898 Mr. Babcock was associated with the San Francisco office of constituent companies of the General Electric group, and from July 1898 until July 1902 was in responsible charge of development work in hydroelectric plants and distribution systems for the Standard Electric Company (Calif.), a pioneer in the California electric utility field. In 1902 he entered the railway field as electrical engineer of the North Shore (Calif.) road, and laid out the first electrification of a steam road to be undertaken on the West Coast. Upon completion of this work he was made electrical engineer of the Southern Pacific system, and later, of all the Harriman lines comprising the rail network from New Orleans and Omaha to the Pacific, and from Spokane, Wash., to Mexico City, and since that time has been responsible for every electrical project of the Southern Pacific. In 1924 he was principal delegate to the Inter-American Commission on Electrical Communication, held in Mexico. As the result of this conference and subsequent discussion with naval officers, he was commissioned for a special service in demonstrating the application of short-wave radio transmission to naval communications. In 1925 he went with the fleet on its Australian cruise, and as the result of his work at that time the navy immediately adapted its communication service to the use of the short waves. Genuinely interested in all new electrical developments, Mr. Babcock also found time for many scientific activities in addition to his regular professional duties. He is a member of the Association for the Advancement of Science and of the Astronomical Society of the Pacific. He is a charter member and past-president of the San Francisco Engineers' Club, and an honorary member of La Sociedad de Geografia Y Estadistica. In addition to serving in other capacities, Mr. Babcock was chairman (1915–16) of the A.I.E.E. San Francisco Section.

F. M. STARR (A'30) of the distribution systems section of the central station engineering department of the General Electric Company, Schenectady, N. Y., has been awarded the 1932 Alfred Noble Prize for his paper "Equivalent Circuits—I," as reported elsewhere in this issue. This paper was presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932. Mr. Starr was born in Fowler, Colo., in 1905, and was graduated from the university of Colorado in 1928 with the degree of B.S. in E.E. In June 1928 he entered the testing department of the General Electric Company at Schenectady, N. Y., and a year later was transferred to the engineering

F. M. STARR

general department. Two years ago he entered the distribution systems section of the central station engineering department, the position which he now holds. He also has taken the company's 3-year advanced course in engineering.

PAUL LEBENBAUM (A'04, M'13) recently was promoted from assistant electrical engineer for the Southern Pacific (railroad)

Company, San Francisco, Calif., to the office of electrical engineer for that company to succeed A. H. Babcock who retired as reported elsewhere in this issue. Mr. Lebenbaum was born in San Francisco, Calif., October 20, 1879. After attending the public schools of that city he entered the College of Mechanics at the University of California, Berkeley, whence he graduated in 1902, immediately to join the test department of the General Electric Company. After serving in that department from May 1901 to May 1902, he served in the company's drafting room until October 1902, subsequent to which he spent a year with the North Shore (Calif.) Railroad, during its electrification. Since 1903 he has been with the Southern Pacific Company. Mr. Lebenbaum has been active in Institute circles on the Pacific Coast, and has served the San Francisco Section in various capacities.

S. H. MORTENSEN (A'09, M'12, F'20) with the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., since 1908 has been appointed by that company as its engineer-in-charge of alternating-current design, succeeding R. B. Williamson who died June 26, 1932, as announced in ELECTRICAL ENGINEERING for August. Mr. Mortensen was born in Eskelund, Denmark, November 4, 1878; was naturalized in 1908. After varied and extensive schooling and apprentice experience he graduated in 1902 from Polytechnicum of Mittweida in Germany, with degrees of Electrical and Mechanical Engineer. In the United States he first served with the Westinghouse Electric and Manufacturing Company (1903–5) and next with the Bullock Electric Company of Cincinnati, Ohio (1905–8) before his connection with his present company.

G. A. MILLS (M'18) until recently an active leader in Institute affairs in the South West District (No. 7) has moved to Lansing, Mich. Mr. Mills, formerly chief engineer for the Central and South West Utilities Company and vice-president for the Pecos Valley Power and Light Company, Dallas, Texas, now is president of the Michigan Gas and Electric Company and the Michigan Public Service Company. As a result of his removal from the South West District, Mr. Mills resigned his Institute vice-presidency representing that District. Mr. Mills was to have served for the 2-year term, August 1, 1932–July 31, 1934. Stanley Stokes of St. Louis is his successor, as announced elsewhere in these columns. A complete biographical sketch of Mr. Mills is given on p. 54 of ELECTRICAL ENGINEERING for January 1932.

L. A. KELLEY (A'21) since 1929 a senior engineer on the staff of the International Communications Laboratories, New York, N. Y., now is a partner in the communication engineering firm of Burkholder and Kelley of New York, N. Y., and Toronto, Ontario, Canada. Mr. Kelley's previous experience includes service with the Signal Corps of the United States Army (1918–19); toll systems development department of the Western Electric Company (1920–24); and subsequently the department of development and research of the American Telephone and Telegraph Company. With the I. C. Laboratories Mr. Kelley was engaged in the design and development of new types of communication systems for use by affiliated companies.

H. S. BENNION (M'27) since September 4, 1926, director of engineering for the National Electric Light Association with offices at that organization's headquarters in New York, N. Y., recently was appointed assistant executive director of the N.E.L.A., according to announcement. Major Bennion was born September 7, 1889, at Vernon, Utah. He graduated from the United States Military Academy at Westpoint, N. Y., in 1912, and from the United States Engineers' School, Washington, D. C., in 1915. From graduation his military activities and service on various government commissions, including extensive service in France, continued up to the time of his original appointment to N.E.L.A. in 1926.

G. C. WARD

G. C. WARD (M'24) for 3 years executive vice-president, and since early in 1932 senior vice-president, of the Southern California Edison Company, Ltd., Los Angeles, Calif., has been named its president by action of the company's board of directors, according to press dispatches under date of October 19. As reported in ELECTRICAL ENGINEERING (March and April 1932, p. 140 and 213) Doctor Ward has been identified with utility engineering and construction since 1882, and with the Edison Company since 1917 when it absorbed the Pacific Light and Power Corporation of which Doctor Ward was president.

W. A. DANIELSON (A'09, M'30) major, Quartermaster Corps, United States Army, recently has been assigned to duty as constructing quartermaster with headquarters in Baltimore, Md., from which he will direct construction of hospitals and quarters at Edgewood Arsenal, Camp Holabird and Forts Meade, Howard, and Hoyle. Major Danielson was transferred to Baltimore from Governors Island, New York, where he was on duty as utilities officer for the Second Corps Area. Previously he had been stationed at Washington, D. C.

P. H. POWERS (A'21, M'30) vice-president in charge of sales of the West Penn Power Company, Pittsburgh, Pa., recently was elected president of the Pennsylvania Electric Association. Mr. Powers' work with the West Penn interests began in his capacity of division manager of the Keystone Power Corporation at Bellefonte, Pa.; in 1924 he was made general manager of that company and in 1928 he became commercial manager of the West Penn Company at Pittsburgh, Pa. Appointment to the vice-presidency followed in 1930.

H. R. REED (A'28) has been promoted from assistant to associate professor of electrical engineering in the Michigan College of Mining and Technology, Houghton. Professor Reed went to Michigan Tech. in the autumn of 1929 from South Dakota State College, Brookings, where he had been an instructor since receiving his M.S. degree from the University of Minnesota in 1927. His special field of interest is transient electrical phenomena, in which he conducts senior and graduate courses and carries on research work.

W. P. SCHWABE (A'96, M'24) manager and director of the Northern Connecticut Power Company (now affiliated with the Connecticut Light and Power Company) Thompsonville, Conn., and a past-president of the New England Division of the National Electric Light Association, has been appointed a director of the Federal Home Loan Bank for the New England district. His headquarters will be at Cambridge, Mass.

J. C. BURKHOLDER (M'30) formerly chief engineer of telegraphs for the Canadian National Railways, Toronto, Ontario, now is senior partner in the recently formed communication engineering firm of Burkholder and Kelley of New York, N. Y., and Toronto. Mr. Burkholder has been widely known for the successful accomplishment, under his direction, of communication with moving trains, and other related developments.

F. J. RUDD (M'19) who heretofore has been serving the General Electric Company, Schenectady, N. Y., as designing engineer of its motor department, now becomes manager of the stationary motor engineering department upon the transfer of L. E. UNDERWOOD (A'03, M'13) to the managership of the Pittsfield (Mass.) works (see ELECTRICAL ENGINEERING, October 1932, p. 748).

B. C. J. WHEATLAKE (A'16) manager of the Salt Lake City, Utah, office of the General Electric Company, has been chosen to care for the arrangements in connection with the Institute's 1933 Pacific Coast Convention, as convention chairman. Mr. Wheatlake already is well known in his local Section activities, in which he has been participating now for some time.

D. W. MCLENEGAN (A'24) who has been serving the General Electric Company at Schenectady, N. Y., as commercial engineer in its industrial engineering department, re-

cently received appointment to the office of assistant engineer of the commercial engineering division of the company's air conditioning department, the formation of which took place only this year.

E. R. HEDRICK (M'25) professor of mathematics and chairman of the department of mathematics of the University of California at Los Angeles, Calif., has received appointment to the chairmanship of the committee on the teaching of mathematics in colleges and universities of the North Central Association of Colleges and Secondary Schools.

D. R. BULLEN (A'02) assistant vice-president of the General Electric Company, Schenectady, N. Y., recently was elected second vice-president of the National Electrical Manufacturers Association, New York, N. Y.

O. A. DEMUTH (A'23, M'30) formerly an electrical engineer with the Stone & Webster Engineering Corporation, Seattle, Wash., now is associated with 4 other former Stone & Webster engineers in the Shannon Engineering Company, Seattle, Wash.

C. W. MITCHELL (M'31) was reelected secretary-treasurer of the southwestern section of the International Association of Electrical Inspectors, at the Santa Barbara, Calif., convention of that organization held September 12–14, 1932.

R. H. GOODWILLIE (A'04) works manager of the Otis Elevator Company, N. Y., recently was elected treasurer of the National Electrical Manufacturers Association, New York, N. Y.

Obituary

CHARLES F. GOOB (M'21) chief engineer for the Baltimore, Md., department of public works, died in Baltimore, September 26, 1932, after a short illness. Mr. Goob was born January 1, 1884, in Baltimore, where he subsequently pursued his education, graduating from the Baltimore Polytechnic Institute in 1901, and completing a postgraduate course there in 1902, in addition to which he pursued a similar course in the mechanical laboratory at Lehigh University, Bethlehem, Pa. From 1902 to 1907 he was successively engaged as a cable tester for the Maryland Telephone Company, draftsman in the chief engineer's office of the Baltimore & Ohio Railroad Company, and draftsman on telephone switchboards for the Western Electric Company at its Hawthorne works, Chicago, Ill. In 1912, acting for the Wilson Maltman Electric Company, he installed all mechanical equipment in the then new Baltimore Polytechnic Institute, where he continued as an instructor of engineering until 1917. From April 6, 1917, until August 31, 1920, Mr. Goob served as an engineer officer in the United States Navy with the rank of lieutenant. Upon his discharge from the navy he became associated with the Electrical Commission of the city of Baltimore as its chief engineer, subsequently heading the bureau of mechanical-electrical service in the Baltimore city government, later becoming the city's chief engineer, a position he filled until his death.

CYPRIEN O'DILLON MAILLOUX (A'84, M'84, F'12, Life Member, past-president) widely known for his active participation in international engineering and scientific standardization work, and for many years prominent as a consulting engineer in New York, N. Y., died suddenly October 4, 1932, at the age of 71, at his home in that city. Dr. Mailloux was a charter member of the Institute and had served it actively and generously through many years. He served 3 terms as manager (1886–9, 1899–1902, 1905–7) 2 terms as vice-president (1898–9, 1902–4), served as president for the year 1913–14, and devoted many years to the Institute's committees including the standards committee, the Edison Medal committee, and the John Fritz Medal board of award. Dr. Mailloux was born at Lowell, Mass., but at an early age he went to New York City where, in pursuit of professional learning, he was one of the leading pupils of Dr. Pupin who at that time was a lecturer on advanced theory of electrical engineering at Columbia University. In its later application, Dr. Mailloux's professional career touched many and diverse channels. In specifically technical work over a period of 25 years, his activities included "responsible charge" and direction of electrical work on more than 800 jobs ranging from 50 to 25,000 kw; perfection of some 100 inventions of which 30 were patented by him, some of these including patents rated as "basic" in connection with the circuit breaker, the booster for d-c circuits, the non-differential d-c arc lamp, and the iron clad multipolar street-car motor. He spent appreciable amounts of time, in addition to his design and construction work, in the giving of expert advice and counsel, the preparation of statistics and reports, and in arbitration work involving many difficult situations that would have sorely taxed many less capable or less patient and persistent. In this last mentioned capacity his extensive knowledge of languages made it possible for him to be the forceful prominent figure that he became in connection with the first, and many subsequent, meetings of the International Electrotechnical Commission. With his ability as an interpreter and his keen insight he soon found himself in the rather vital rôle of liaison officer. In the I.E.C. Dr. Mailloux has been president (1919–23), director, secretariat on nomenclature, and at the time of his death, honorary president; and on the U.S. national committee of the I.E.C., he has been president (1914–24) chairman, advisor on nomenclature, representative on division of foreign relations. In the International Conference on Large Electric High-Tension Systems in Paris, he was honorary president, acting also as United States delegate at recent biennial meetings. Today the I.E.C. probably is one of the largest cooperative international factors working for the advancement of the electrical profession. Doctor Mailloux was an ardent advocate of a universal language on technical terms—a scientific *esperanto*—which he contended would give the United States, already controlling a heavy percentage of the world's electrical industry, a medium almost invaluable for the promulgation of professional progress. Dr. Mailloux was a liberal contributor to technical literature, and through his effort the electrical engineering nucleus of the present Engineering Societies Library in New York had its origin. In 1902–3 he, himself, donated certain volumes and subscriptions to certain technical periodicals to the library of the electrical engineers, providing maintenance for these sets of books and periodicals by a gift of $1,000 "to be . . . invested . . . the proceeds . . . to be used partly each year for the subscription . . . to the serial publications donated and partly for the binding of said publications." Administration of this fund, still extant and known as the Mailloux Fund, subsequently was modified by the donor to permit the expenditure of moneys accruing from it for "books, periodicals, or other publications in the French language relating to either electrical engineering, mathematical physics and pure mathematics"; its present application represents a still further broadening of these stipulations to include writings other than in French.

FREDERICK WILLIAM KELLEY (A'05) president of the North American Cement Corporation, Albany, N. Y., and former president of the Albany Chamber of Commerce, died September 19, 1932, after a period of continued ill health. Albany was his birthplace (1870) and after attending the Albany Boys Academy for a while, he went to public school in Toledo, Ohio, later also attending the Toledo Manual Training School. In 1893 he was graduated from Cornell University with his degree of M.E.; during this course he took considerable electrical engineering work also but not enough to win him an additional degree. In 1894 he was engaged by the Consolidated Car Heating Company of Albany as draftsman, but so successful a career did he create for himself that he became successively assistant treasurer, treasurer, and general manager of his firm. In 1900 he joined the Helderberg Cement Company of Albany and until 1905 was its vice-president and general manager. In 1925 his company merged with the Security Cement and Lime Company of Maryland and Mr. Kelley who in 1914 had been elected president of his own company now became president of the new organization, the North American Cement Corporation. He later became president of the Portland Cement Association of America. Various other organizations of which he was a member and an officer at the time of his death include: the National Commercial Bank and Trust Company, vice-president; City Savings Bank, trustee; Consolidated Car Heating Company, director (and former president); Albany Hospital, president; Albany Medical College, Albany Academy, Albany Institute of History and Art, and the Dudley

Observatory, trustee; Commercial Safe Deposit Corporation, director; and a member of the board of governors of Union University. Mr. Kelley also held membership in The American Society of Mechanical Engineers, the American Society for Testing Materials, the American Concrete Institute, the Albany Society of Engineers, and the Society of Engineers of Eastern New York, of which he was a past-president.

HARRY ALEXANDER (A'91, M'17, F'20) long-time electrical contractor with headquarters in New York, died October 18, 1932, at his home in Kings Point, N. Y., as a result of gunshot wounds obviously self-inflicted. It is reported that Mr. Alexander had been suffering for some years from heart trouble. Mr. Alexander was born August 6, 1871, in New York City, according to his A.I.E.E. application made under date of April 21, 1891, although current newspaper reports give Lynn, Mass., as his birthplace. After a common school education he is credited with continuing his education through reading, night study, and practical experience. He was early (1888) connected with the Thomson-Houston Electric Company at Lynn, subsequently becoming a machine shop superintendent for the Thomson Van Depoels Company of Dover, N. H., manufacturers of mining machinery. In the latter part of 1891 he went to New York City as a member of the electrical contracting firm Alexander-Chamberlain Electric Company, which later in the same year became Harry Alexander, Inc. Electrical installations credited to him include the White House in Washington, D. C., and stores and office buildings in various eastern and middlewestern cities including New York, Baltimore, St. Louis, and Boston. He is credited with being the contractor for the original East Side (N. Y.) terminal work of the New York Central Railroad in connection with its Grand Central station (1907); patenting an interior conduit system (1906–7); being a sub-contracting engineer for substation and construction work for the United Railway of Havana (1909); and with patenting the "Alexalite" indirect lighting diffuser (1911). During 1917 and 1918 he was associated with the provision of electric power facilities at the U.S. naval transport terminal in Hoboken, N. J. He was a member of The American Society of Mechanical Engineers.

MALCOLM PERCY RYDER (A'01, M'14) mechanical and electrical engineer at Westfield, Mass., died suddenly May 24, 1932 of heart disease. Mr. Ryder was born in Ossining, N. Y., February 22, 1874, and after high school attendance acquired his early technical education chiefly by home study in conjunction with such practical work as he found. In 1890 he engaged with the Edison Machine Works, predecessors of the General Electric Company, Schenectady, N. Y., taking the student course in shop-work and spending a considerable amount of time in the testing department. In 1892 he went to the Thomas A. Edison iron ore separating works in charge of separators and the electrical plant, a year later joining the General Electric Company's Lynn Works for a special course in arc lighting and a-c work. The year 1893 was spent in Maracaibo, Venezuela, in charge of the central station of the Maracaibo Electric Light Company; then he returned to New York as electrical engineer in charge of the central station of the North River Electric Light and Power Company, later to become its superintendent of central stations for a period of 2 years. The C & C Electric Company of Garwood, N. J., called him as foreman of the winding and testing departments for a year, after which he returned to New York City as wire contractor. In 1899 the New York Edison Company made him superintendent of its Bronx District, a position which he held until 1909, when he removed to Springfield, Mass., to become engineer of the Witherbee Igniter Company, in charge of design and production of ignition apparatus for internal combustion engines. He later invented a novel type of magneto generator which was manufactured by the Witherbee Company. Remaining with this firm until 1919 he then withdrew and took up residence in Westfield, Mass., his home at the time of his death.

WILLIAM LAMB DODGE (M'26) telephone engineer, Bell Telephone Laboratories, Inc., New York, N. Y., died April 7, 1932. Mr. Dodge was born at Clinton, Maine, in 1885, and in 1902 attended Coburn Institute, subsequently winning his degree of A.B. from Colby College, Maine, in 1906. For 2 years thereafter he was engaged in a student course of the Western Electric Company, working also in the installation department of that company. In 1908 he identified himself with the plant department of the New York and New Jersey Telephone Company, a year later joining the plant department of the New England Telephone Company. Here he remained until 1917, when he engaged with the Western Electric Company's engineering department and the Bell Telephone Laboratories, first for the design of manual and machine switching telephone systems, later as engineering department representative in charge of a group of engineers on the first panel machine switching central office placed in service, and still later for $3^1/_2$ years in charge of one or more groups of engineers engaged in the design of machine switching systems of the panel type and the step-by-step type. Mr. Dodge's work has involved the engineering of many important projects and has placed him in charge of highly essential development work.

J. R. GILROY (A'26) injured in an automobile accident May 1, 1932, died September 5 as the result of the accident. Mr. Gilroy was injured at Champaign, Ill., where he had been living while attending the University of Illinois at Urbana. Mr. Gilroy was born in Scotland, June 29, 1903, but pursued his grade and high school education in the United States, after which he graduated from Bliss Electrical School in Washington, D. C., subsequently attending Armour Institute of Technology in Chicago during the period of his employment in the testing laboratory and later in the operating department of the Commonwealth Edison Company of Chicago.

NEEL BULLOCK (A'32) who this past summer completed his college course at the University of Alabama, University, Ala., and obtained his degree of B.S. in E.E., was accidentally drowned in St. Andrews Bay, St. Andrews, Fla., August 21, 1932, while out with a boating party. Mr. Bullock was born in St. Andrews, December 20, 1909. He had spent the summer of 1930 in the drafting department of the Southern Kraft Corporation.

Local Meetings

Future Section Meetings

Detroit-Ann Arbor

November 15, at Jackson, Mich.—SWITCHGEAR. To be discussed by members of the local Section.

December 13, at Detroit, Mich.—ELECTRIC MOTORS AND THEIR APPLICATIONS, by A. M. Dudley, Westinghouse Elec. & Mfg. Co.

Pittsfield

November 1—JAPAN, CHINA, AND THE WHITE MAN, by Upton Close.

November 15—AIR CONDITIONING—PERFECT WEATHER IN YOUR HOME 365 DAYS A YEAR.

Lehigh Valley

November 18, at Elks Club, Hazleton. THE UNSEEN CONDUCTOR, by Glenn Appleman, Pennsylvania Pwr. & Lt. Co.

New York

November 29—Second meeting of the power group: meeting devoted to "Rectifiers and Electronic Devices." C. A. Butcher, Westinghouse Elec. and Mfg. Co., will present "Power Rectifiers" and W. S. Hill, Gen. Elec. Co., will discuss "Power Applications of Electronic Devices." Mercury arc rectifiers, now firmly established in the electric traction field, give promise of becoming practical for low voltage commercial service. Possible application to metropolitan networks will be mentioned. Electronic devices have many present applications and great future possibilities in power and control fields. Distinctions between the various types of tubes together with their applications will be explained. The meeting will convene at 7:30 p.m. and will be adjourned promptly at 9:30 p.m. Non-members are welcome. Discussion is open to all. The location will be Room 1, Fifth Floor, Engineering Societies Building.

Past Section Meetings

Birmingham

Discussion of future plans and reorganization of Section. Election of officers: Howard Duryea, chmn.; H. M. Woodward, secy. Sept. 30. Att. 18.

Chicago

Operation of Electrical Machinery in Special Media, by C. J. Fechheimer, consulting engr. Dinner. Sept. 26. Att. 67.

Cincinnati

Program Transmission for Broadcasting Stations, by Leo Friedman, American Tel. & Tel. Co. Inspection of the control room in the telephone building. Sept. 22. Att. 112.

Dallas

Short talks by B. D. Hull, Southwestern Bell Tel. Co., O. S. Hockaday, Texas Pwr. & Lt. Co., and J. B. Thomas, Texas Elec. Serv. Co. Sept. 19. Att. 50.

Denver

Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres. A.I.E.E., vice-pres. Bell Tel. Labs., Inc. Dinner. Sept. 23. Att. 170.

Detroit-Ann Arbor

Hunting Vertebrate Fossils, by Prof. E. C. Case, Univ. of Mich. Dinner. Sept. 20. Att. 68.

Erie

Electric Cables, by F. V. Calvert, Gen. Elec. Co. Sept. 20. Att. 25.

Houston

The Ultimate Particle, by H. A. Wilson, Rice Institute. Sept. 30. Att. 51.

Kansas City

Reports of the summer convention held in Cleveland, Ohio, by A. E. Bettis, Kansas City Pwr. & Lt. Co., R. M. Ryan, Gen. Elec. Co., D. C. Jackson and Robert Warner, both of the University of Kansas. Sept. 26. Att. 65.

Los Angeles

Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres. A.I.E.E., vice-pres. Bell Tel. Labs., Inc. Illustrations. Dinner. Sept. 15. Att. 174.

Memphis

Organization and Operation of a Weather Bureau Station, by F. W. Brist, U.S. Weather Bureau Station. Sept. 20. Att. 35.

Mexico

Modern Methods of Vertical Transportation, by A. de la Torre, and W. B. Ferguson, Westinghouse Elec. & Mfg. Co. Election of officers: W. A. Schulenburg, chmn.; L. Castro, Jr., secy.; F. Aubert, treas. Sept. 21. Att. 32.

Montana

Business meeting. Sept. 16. Att. 12.

Nebraska

Prof. M. S. Coover, District Secy., Univ. of Colorado, and Dean O. J. Ferguson, Univ. of Nebraska, spoke on the value of membership in the A.I.E.E. A. L. Turner gave a report of the Summer Convention held in Cleveland, Ohio. Dinner. Sept. 30. Att. 25.

Niagara Frontier

Foreign Influences on American Business, by Prof. P. W. Bidwell, Univ. of Buffalo. Dinner. Sept. 16. Att. 55.

Oklahoma City

Executive committee meeting. Sept. 2. Att. 11.

Low and Medium Voltage Networks, by Frank Kasper, Byllesby Engg. & Mngt. Corp. Sept. 22. Att. 99.

Pittsburgh

The Theory and Operation of the Surge Generator and Cathode Ray Oscillograph, by E. R. Whitehead; Practical Applications and Results Obtained by Use of Surge Generator, by D. B. Perrin. Inspection trip through the laboratories of the Duquesne Light Co. Sept. 20. Att. 220.

Portland

Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres. A.I.E.E., vice-pres. Bell. Tel. Labs., Inc. Dinner. Sept. 9. Att. 93.

Rochester

Sunlight, by Dr. Brian O'Brien, Univ. of Rochester. Joint meeting with I.R.E. and Rochester Engg. Soc. Oct. 6. Att. 90.

St. Louis

Social meeting. Sept. 30. Att. 110.

San Francisco

Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres. A.I.E.E., vice-pres. Bell Tel. Labs., Inc. Sept. 13. Att. 121.

Saskatchewan

Recent Developments in Switch Gear, by L. B. Chubbuck, Canadian Westinghouse Co., vice-pres. A.I.E.E. Sept. 7. Att. 27.

Operation of Diesel Engines, by Charles Day, Mirrless Bickerton & Day. Sept. 12. Att. 32.

Springfield

Lightning Proof Designs of Transmission Lines, by H. R. Stewart, Westinghouse Elec. & Mfg. Co. Illustrated. Sept. 12. Att. 46.

Toronto

The Houses of Life, by Rev. W. J. Johnstone, Eglinton United Church. Sept. 30. Att. 85.

Past Branch Meetings

Alabama Polytechnic Institute

Business meeting. Aug. 29. Att. 20.

The Engineer's Place in the Sun, by Dean W. E. Freeman, Univ. of Kentucky, vice-pres. A.I.E.E. Oct. 6. Att. 31.

University of Alabama

Discussion of activities for the coming year. Sept. 26. Att. 20.

University of Arkansas

Branch activities were discussed by Prof. W. B. Stelzner, counselor, and L. Wasson, chmn. Sept. 22. Att. 24.

Bucknell University

Discussion. Oct. 5. Att. 14.

University of California

Power and Economic Basis for Power Transmission, by Prof. W. A. Hillebrand. Film—"A Trip Through the G.E. Plants." Sept. 7. Att. 46.

Cornell University

The Organization of the A.I.E.E., by Prof. R. F. Chamberlain; The Early Controversy Between A.C. and D.C. Systems, by Prof. P. M. Lincoln; Photoelectric Cell Applications, by L. F. Moyle, student. Prof. E. M. Strong, counselor, outlined future plans. Oct. 7. Att. 32.

University of Denver

Films—"The Electric Ship" and "The Panama Canal." Sept. 27. Att. 20.

Drexel Institute

Modern Chain Broadcast Circuits, by J. J. Jaeger, student. Oct. 5. Att. 20.

University of Florida

Opportunities in Engineering and How to Prepare for Them, by Prof. Joseph Well, counselor; Florida as a Come-Back State, by Dean Van Leer. Oct. 3. Att. 90.

Marquette University

Board meeting. Sept. 15. Att. 6.

Discussion of proposed constitution. Sept. 22. Att. 13.

Application of Radio to Police Service, by Mr. Wareing, chief engr., Police Radio Broadcasting Dept. Oct. 6. Att. 32.

Michigan State College

Business meeting. Oct. 5. Att. 16.

Mississippi State College

General discussion. F. G. Marble elected secy. Sept. 22. Att. 27.

University of Missouri

Prof. M. P. Weinbach, counselor, outlined the history, purpose, and organization of the A.I.E.E. Raymond L. McGirl elected secy.-treas. Oct. 5. Att. 25.

Montana State College

Prof. J. A. Thaler, counselor, outlined the E.E. seminar meetings. R. S. Stokan, chmn., gave a report of the Pacific Coast convention at Vancouver, B.C. R. V. Bauer, student, outlined the purpose and organization of the local Branch. Oct. 6. Att. 101.

University of Nebraska

Inspection trip through the power and heating plant of the Lincoln Hotel. Election of officers: John Hutchings, chmn.; Arnold Coffin, vice-chmn.; Charles Devore, secy.-treas. Oct. 5. Att. 22.

Newark College of Engineering

Value of Student Societies, by A. R. Cullimore; Branch Activities, by Prof. J. C. Peet, counselor. Sept. 26. Att. 35.

University of New Mexico

Election of officers: Stanley O. Fish, chmn., Martin Zirhut, secy.-treas. Oct. 5. Att. 6.

College of the City of New York

Business meeting. Sept. 29. Att. 17.

John Ragazzini, chmn., spoke on the advantages of membership in the A.I.E.E. Oct. 6. Att. 34.

North Carolina State College

Aims and Purposes of the A.I.E.E., by D. M. House, student; Benefits of the A.I.E.E., by Prof. W. H. Browne, Jr.; Section and District Conventions of A.I.E.E., by Prof. R. S. Fouraker, counselor. Oct. 4. Att. 106.

University of Notre Dame

Dr. J. A. Caparo, counselor, outlined the distinction between the local and national benefits of the Institute, and spoke of the advantages afforded by each. Oct. 3. Att. 75.

Oklahoma A. & M. College

The Engineering Field in General as Judged From My Experiences, by Prof. J. E. Kirkham. John R. Hollis elected chmn.; Romus Soucek elected vice-chmn. Sept. 19. Att. 26.

Purdue University

The Activities and Purpose of the A.I.E.E., by Prof. C. F. Harding; The History of the A.I.E.E. and Its Value to the Student, by Prof. A. N. Topping, counselor; The Indianapolis-Lafayette Section of the A.I.E.E. and the Presenting of Articles to the Branch by Students, by Prof. D. D. Ewing. Sept. 29. Att. 210.

Rhode Island State College

Power Distribution in Tall Buildings, by M. Afootian, student. Oct. 5. Att. 20.

Rose Polytechnic Institute

Relation of A.I.E.E. to the Student Engineer, by Prof. C. C. Knipmeyer, counselor. Oct. 3. Att. 31.

Southern Methodist University

Film—"The Wizardry of Wireless." Oct. 6. Att. 9.

Virginia Polytechnic Institute

Flame-Proof Gasoline, by S. L. Butler, student; Electrical Accidents and Their Treatment, by B. G. Belote, student; Niagara-Hudson Power Plant, by H. C. Epperly, student; Electric Machines for Cooling Milk, by B. R. Pogue, student. Oct. 6. Att. 41.

The Great Northern Railway Electrification, by W. P. Swartz, student; Typographs for Bandits, by J. E. Hamm, student; New York City's New Electrical Bank Building, by J. A. M. Maddox, student. Sept. 29. Att. 43.

State College of Washington

Dean H. V. Carpenter outlined the proceedings of the annual summer convention held in Cleveland, Ohio. William E. Bratt elected secy. Sept. 30. Att. 15.

West Virginia University

AUTOMATIC COMBUSTION CONTROL, by C. B. Sims; DIRECT READING OHM-METER, by G. F. Lefevre; INSTRUMENT TRANSFORMERS, by F. Q. Brown; USE OF ELECTRICAL POWER ON SHIPS, by J. Millard; AIR TRANSPORTATION, by P. M. Vannoy; ELECTRIC SERVICE TO MORGANTOWN, by L. P. Lovett; HISTORY OF MICHAEL FARADAY, by E. C. McMillan, all students. Sept. 26. Att. 24.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Combustion

PWR. ENGR., mech. and elec., 43, American, college graduate. Past 3 yr. with prominent engg. organization correlating design engg. work for large central station and industrial pwr. plant projects. Previous 4 yr. rebuilding and operating pwr. plant of large eastern copper refinery. Broad experience. D-986.

Construction

GRAD. E.E., 29, five yr. supervisory construction, design, estimating and field engg. experience on super-pwr. plants, substations; 4 yr. industrial power plant operation. Elec. construction and maintenance experience; ry. electrification construction experience. C-4428.

Design and Development

MECH.-ELEC. ENGR., 32, 4 years' Cornell design instructor; 5 yr. Allis-Chalmers design; liberal shop experience; 5 yr. cooperative apprenticeship. Will consider anything, anywhere. Now available. Salary open. D-122.

JUNIOR ENGR., desires employment where high grade technical knowledge is required. Has had laboratory experience. Familiar with elevator service work and elevator parts design. Go anywhere. C-9963.

ELEC. ENGG. GRAD., 28, married, desires position in design and development or teaching. One year Westinghouse student course; 6 months Westinghouse design school; 1½ yr. design of fractional hp. motors; 2½ yr. design of industrial motors. Available at once. Location, U.S. C-5051.

ELEC. ENGR. and designer, 36, married with 20 yr. experience in pwr. and industrial plant operation, design, estimating and planning. Also experience in traction and mining pwr. supply. Last 7 yr. with leading construction engrs. Good references regarding character, personality, cooperative nature, and ability. Permanent position preferred. Salary reasonable. D-1552.

Executives

ELEC. ENGR., grad., 42, 5 yr. supervision elec. maintenance r.r. Six yr. head elec. and mech. maintenance group 18 coal mines. Eight yr. assoc. editor coal mining magazine, experienced equipment photography, wide acquaintance, numerous excellent references. B-7563.

ELEC. ENGR., E.E. degree. 14 yr. experience public utilities covering valuation work, rate investigations, engg. pwr. plants, substations, transmission lines, including estimates, specifications, design. Experience covers short circuit studies, stability analysis, investigations of systems for load conditions. Desires position, holding company, operating company, or engg. firm. Available immediately. C-9670.

ELEC. ENGR., married, E.E., M.E. 22 yr. experience, designing, construction pwr. plants substations, transmission, distribution systems, and industrial plants. 3 yr. charge purchasing engineering equipment, foreign interests. 3 yr. exec. experience charge engg. department large utility syndicate. English, German, Russian, Armenian, Turkish languages. Available immediately. D-84.

E.E. DEG., 30. Some training in mech. and civil engg., business administration. Sales experience as district representative handling all local sales activities; special sales representative on sales promotion, and technical sales representative. Elec. testing as asst. elec. engr., Underwriter's Laboratories. Also elec. contracting; building construction and specifications experience. Available immediately. D-1344.

ELEC. GRAD., 38, 17 yr. experience, construction, installation, maintenance, inspection, tests, pwr. plant and substations, distribution (high and low tension), one yr. operating, familiar with South America; speaks several languages. Available at once, home or abroad. Best of references. C-2021.

GRAD. E.E., age 31. Ten yr. experience in public utility and industrial work, covering overhead and underground distribution and transmission installations, electrification of industrial plants, standardization of distribution systems. Headed division for study of industrial plant standardization, also research and analysis pertaining to public utility economics. B-6934.

CANADIAN E.E., 28, single. Would take charge servicing and repair shop, Canada or abroad. 8 yr. practical experience all winding and repair work. 3 yr. supervising, estimates, sales engg. Experience in Westinghouse & G.E. service shops. Can handle men. Licensed as e.e. by professional examination Western Canada. C-8336.

TECH. & BUS. ADMIN. GRAD. Lowell Institute School, auspices M.I.T., elec. and mech. courses; B.B.A. deg. from Boston Univ. also grad. work in management. 14 yr. experience operating, elec. design and engg. Desires position with utility or industrial concern. Location in U.S. immaterial. D-1600.

Inspection

ELEC. GRAD., 38, single. 6 yr. experience factory testing—W. E. & M. Co., East Pittsburgh, Pa. One yr. steel company installing and testing elec. equipment. 6 months' factory inspection of transformers. 2½ yr. general inspection of elec. equipment with insurance company. Good reference. Available immediately. Any location. D-1461.

Junior Engineers

1932 GRAD., E.E., B.S., Univ. of Maine. Honor student, Tau Beta Pi, Phi Kappa Phi, 23, single, and excellent physical condition. Best of character. Willing to start at bottom and work up. Wage of secondary importance. Location, Eastern States. Available immediately. D-1509.

B.S., M.S., in E.E., cooperative course, M.I.T., 1932; 22 single. Good scholastic record. Short experience at G.E. machine shop on test and res. lab. Aggressive, willing, capable of assuming responsibility. References available. Location, immaterial. Available immediately. Salary secondary. Interested, any position which requires engg. background and which offers a future. D-1511.

JUNIOR ENGR., grad. Pratt Inst., industrial elec. engg., 24, single, 2 yr. maintenance department N. Y. Tel. Co. 6 months' layout and installation heavy elec. equipment. Available immediately. Location, immaterial. D-1471.

B.E.E., Ohio State Univ., 1932, single, 22. Assoc. member of Sigma Xi. High scholastic record and reading knowledge of German. Specialized in communication work, but will consider any engg. work. Location and salary, immaterial. D-1523.

GRAD. E.E., Columbia Univ., 6 yr. course, 1932; single, 24; desires work with utility, railroad, mfg. concern or construction corp. Would like to teach e.e. subjects. Location and salary, immaterial. D-893.

ELEC. ENGG. GRAD. '31. Desires position on land or water (prefer water) as assistant to pwr. plant operator. Employed at present, mfg., heating and ventilating equipment. Available on short notice. References. Location and salary immaterial providing there is a chance for advancement. D-1535.

1931 GRAD., E.E., B.S., leading western univ., 27, single. Telephone work, machine shop apprenticeship, draftsman and machine designer, familiar with vacuum tubes, good mathematician. Excellent scholastic record. English, German, Swedish, Finnish, and Spanish languages. Desires position with industrial firm. Location, immaterial. U.S. or abroad. Available on short notice. D-923.

ELEC. ENGG. GRAD., M.I.T., S.B., S.M., class of '31, age 23, single. 10 months' test and research experience with G.E. Desirous of a position in e.e. field with chance for advancement. Available at once. Location, immaterial. D-1538.

JUNIOR ELEC. ENGR., B.S., 23, grad. specialized course in a-c and d-c motor and generator engg. and testing, invites correspondence leading to permanent connection with established company desiring to develop production, designing, or equipment engr. Would expect shop experience as training for exec. position later. Location, immaterial. D-1543.

B.S. in E.E. in 1932, age 24, single. Experience in mech. engg., elec. engineering, drafting, and design. Prefer exec. type of work but will consider any position with a future. Location in the East. D-1497.

B.S. in E.E., 1932, 24, single. Desires engg. work of any kind. Salary and location secondary. Available immediately. D-1559.

E.E. GRAD., 1929, 25, single. 2½ yr. experience in design and engg. of high tension outdoor and indoor substations. Desires position connected with hydroelectric development. Location desired, South. C-5967.

E.E. GRAD., M.I.T., B.S. 1931, M.S. 1932, 23, single. 16 months' cooperative training with Edison Elec. Illum. Co. of Boston. Temporarily engaged in retail sales of elec. appliances. Desires connection with utility or mfr. leading to a position in the field of engg. management. Location preferred East or Middlewest. D-1565.

E.E. GRAD., 1932, Rensselaer P.I., 22, single. Desires work in any elec. field. Salary and location, immaterial. Available at once. D-1296.

E.E. GRAD., 1932, Northeastern Univ., 22, single, excellent physical condition. Has had 1½

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco

205 West Wacker Drive
Chicago

31 West 39th St.
New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge, repeated only upon specific request and after one month's interval. Names and records remain on file for three months, renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answer to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra three-cent stamp enclosed for forwarding.

yr. experience as cooperative student in experimental lab. of radio condenser concern. Desires position in any field of engg. with opportunity for experience. Location and salary, immaterial. Available immediately. D-1571.

UNIV. OF MICH., 1932 grad. B.S. in E.E., 22, single, excellent physical condition. Best of character and hard worker. Two summers with Mich. Bell Tel. Co. Prefers work in elec. field, but interested in management and personnel work. Location, immaterial. Available immediately. Desires position with future. D-1572.

E.E. GRAD., 1932, Miss. State Col., 22, single. Desires engg. work, but will consider anything. Location, immaterial. Available immediately. D-1570.

M.E.; M.S., 26, single. 4 yr. experience in telephone work. Desires teaching or engg. work of any nature except sales. Available immediately. Location, immaterial. D-1225.

1932 CORNELL GRAD., 22, single. Broad education with major in communications. Good scholastic record. Desires work, preferably on telephone, radio or sound equipment. Location desired East. Salary, immaterial. Available immediately. D-1558.

E.E. GRAD., 1932, M.I.T., M.S., 23, single, one yr. G.E. test. Desires work in elec. machine design and development. Available immediately. D-1579.

B.S. in E.E., 1932, 23, single. Desires position with utility or mfg. concern, preferably in field of radio, power transmission, or elec. ry. engg. Will work at anything if only given a chance to enter an engg. house. Available at once, location and salary, immaterial. D-1546.

M.S. in E.E., '32, B.S., '31; Moore School of Elec. Eng., Univ. of Pa. Grad. work in acoustics, electronics and business admin.; teaching experience and experience in the writing of technical papers for publication. Fluent knowledge of German language. Wants responsible work. Location, immaterial; available on one week's notice. D-1585.

GRAD. 1932, B.S. in E.E., Clarkson Col. Grad. 1929 Rochester Atheneum & Mechanic's Inst., diploma in E.E. 2 yr. factory experience in radio and telephone. Desires to work up. Available immediately. Location, immaterial. D-1583.

E.E. GRAD., 1929, Lehigh Univ., married. Post grad. work in business finance and sales. Completed 3 yr. cadet engr. training course of Public Service Elec. & Gas Co., involving work in generation, distribution, commercial and sales departments. Excellent references. Desires position with future. Available immediately. D-1566.

B.S. in E.E., 1932, Purdue Univ., single, 21, desires position in any engg. field. Location, immaterial. Available immediately. D-1588.

E.E. GRAD., Univ. of Minn., 1930, 25, single. 2 yr. experience with large midwest pwr. company, including one yr. training course and one yr. distribution and transmission engg. experience. Available immediately. Location and salary, immaterial. D-1590.

E.E. GRAD., Lehigh U., '31, 24, single. 2 yr. experience elec. const., maintenance, repair in utility field. Thorough knowledge a-c network system of distribution. Majored in elec. traction, elec. design. Special training in writing for trade journals, reports. Will accept offer any field. Location, immaterial, foreign service if possible. Available immediately. D-1540.

B.S. and E.E., '31, Mich. State Col., G.E. test, 4 yr. practical experience with (manual, supervisory controlled, and automatic) pwr. substations, automatic sub-stations (rotary converter and rectifier) and (frame mounted, cell mounted and metal clad) equipment. Willing to do engg., operating, or teaching. D-1597.

B.S. in E.E., 1930, single, 24. Best references following experience: 1½ yr. construction, operation, steam plants, 1½ yr. industrial sales representative N. Y. corporation, 6 months' westinghouse "central station sales" student work. One yr. elec. maintenance work. Recently night engr., refrigeration and ice mfg. plant. Will go anywhere. Suited to utility. Available. D-1599.

Research

ENGR., 28, married, B.S., M.I.T. '30 (honor group), Westinghouse engg. school and design school, 2 yr. experience on solution of special problems, stability studies, transmission lines, experienced in use of symmetrical components, Heaviside's theory and general circuit theory. Available immediately. Location, immaterial. D-1530-329-C-1-San Francisco.

E.E. GRAD., Northeastern Univ., cooperative plan, 1931, B.E.E., 24, single, 3½ yr. experience, research and development on syn. elec. clocks for large elec. clock mfr. in East. Has had general engg. experience pertaining to frequency control installation and design. Desires anything in the field. Location and salary secondary. Available immediately. D-1584.

Sales

GRAD. E.E. with 12 yr. sales and advertising experience available. Excellent references from leading mfr. and publisher. Middlewest location preferred. Age 34, married. Strong salesman with excellent contacts in Middlewest. B-8614.

DISTRICT SALES MANAGER OR MFR'S AGENT: experienced engg. representative, desires connection with high grade company that has line of industrial or utility equipment. Eastern location preferred. B-4067.

Membership

Recommended for Transfer

The Board of Examiners, at its meeting held September 28, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the acting national secretary.

To Grade of Fellow

Caparo, Jose Angel, head, E. E. Dept., Univ. of Notre Dame, Ind.
Hickok, Robert D., pres., Hickok Elec. Instrument Co., Cleveland, Ohio.

To Grade of Member

Anton, George F., asst. prof. in E. E. and physics, Univ. of Porto Rico, Mayaguez, P. R.
Dible, Harvey J., transmission and protection engr., Ohio Bell Tel. Co., Cleveland.
Dow, William G., asst. prof. of E. E., Univ. of Michigan, Ann Arbor.
Edgerton, Harold E., asst. prof. of E. E., Mass. Inst. of Tech., Cambridge.
Lockwood, Earle L., distribution engr., Pub. Serv. Co., Newport News.
MacGregor, Willard H., 217–22 Bayside Blvd., Bayside, L. I.
Milton, Robert M., asst. E. E., U.S. Engr. Office, New Orleans, La.
Noertker, Joseph A., E. E., Cincinnati St. Ry. Co., Ohio.
Pike, Noel, dist. pwr. supt., Guanajuato Pwr. & Elec. Co., Guanajuato, Gto., Mexico.
Reukema, Lester E., assoc. prof. of E. E., Univ. of California, Berkeley.
Schregardus, Dirk, transmission engr., Ohio Bell Tel. Co., Cleveland.
Thomas, Richard N., Borough E. E., Lyttelton, N. Z.
Watson, Malcolm Vau, vice-pres. and genl. mgr., West Coast Pwr. Co.; Calif. Pub. Serv. Co.; Western States Utilities Co., Portland, Ore.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Nov. 30, 1932.

Anderson, L. F., Hotel Riviera, 169 Clinton Ave., Newark, N. J.
Benson, I., 57 Ashland Ave., East Orange, N. J.
Bozenschultz, E. J., The Home Tel. & Tel. Co., Ft. Wayne, Ind.
Brandler, A. B., Royal Switchboard Co., N. Y. City.
Cooper, R. E., Jr., Air Corps, U. S. A., March Field, Calif.
Donovan, A. C., Jr., 34 Manchester Rd., Brookline, Mass.
Bash, C. D., (Member), Consumers Pwr. Co., Jackson, Mich.
Erskine, G., Erskine Elec. Wk., Redwood City, Calif.
Foerner, G., 11 a, West End Ave., Bklyn., N. Y.
Forbin, A. F., Newport News Shipbuilding & Dry Dock Co., Va.
Hield, R. F. (Member), Crompton Parkinson, (Canada), Ltd., Montreal.
Kramer, J. E., Kramer Bros., San Francisco, Calif.
Laverty, C. A., Boiler Inspection & Ins. Co., Montreal, P. Q., Canada.
Lee, J. D., Jr., 19 Marine Ave., Bklyn., N. Y.
Martin, H. E. Waterbury Cable Serv., Inc., N. Y. City.
McRae, D. M., Grain Ins. & Guarantee Co., Winnipeg, Manitoba, Can.
Meltvedt, H., (Member), 421 Franklin St., Downers Grove, Ill.
Miller, A. P., 111 Fulton St., Bloomfield, N. J.
Murray, T. E., Jr., (Fellow), Metropolitan Eng. Co. & Metropolitan Device Corp., Brooklyn, N. Y.
Peterson, G. C., 15 Douglas Place, Verona, N. J.
Rosin, A., (Member) Boro. of Richmond, Clove Pumping Sta., Ontario St., Staten Island, N. Y.
Stanley, C. M., Young & Stanley, Inc., Muscatine, Iowa.
St. Laurent, H., Radio Research Lab., Inc., Yonkers, N. Y.
Travis, I., Univ. of Pa., Philadelphia.
Van Sickle, L. R., 416 E. 17th Ave., Denver, Colo.
25 Domestic

Foreign

Alizo, C., Antonio Cia. Anmma., Planta Elec. de Valera, Est. Trujillo, Venezuela, S. A.
Fountaun, W. C., 16 Bondcoran Parade, Mont Albert, Melbourne, Australia.
Kesavan, K. V., Pwr. Station, Kottayam Travancore, So. India.
Lautier, V., 37 Sda. San Paolo, Cospicua, Malta.
Rozario, J. F. T., Pub. Wks. Dept., Madras Govt., Madras, India.
Sarda, P. M., Ratan Pole, Nagori Pole, Ahmedabad, India.
Singh, H., Simla Municipal Committee Idgah, Simla, India.
Swami, T. V., Elec. Dept., Cocanada, India.
Tharani, J. J., Elec. Pwr. House Veraval, Kathiawar, Manavadar, India.
9 Foreign

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Bohner, C. W., 620—22nd Terrace, Miami, Fla.
Brock, Geo., 1117 N. 15th St., Milwaukee, Wis.
Dalas, F. L., Boulder City, Nev.
Deney, Roger W., 685 Sumner-Atlantic Ave., Forest Hills Boro, Pittsburgh, Pa.
Florez-Estrada, Jose, Avenida De La Paz 60, Reparto Alture-Rio Almendares, Marianao, Havana, Cuba.
Gooding, Chas. C., 1414 K St., Sacramento, Calif.
Jefferson, H. F., 633 Portola Ave., Glendale, Calif.
Keiser, Morris, 1025 King St., Alexandria, Va.
Keller, Dr. Max Leo, Kornweg 8, Aarau, Switzerland.
McShane, Joe B., 810 Western Natl. Bldg., San Antonio, Texas.
Newman, Rexford C., 100 High St., St. Clairaville, Ohio.
Nimetz, John B., 3442 Sacramento St., San Francisco, Calif.
Olsen, V., P. O. Box 404, Shanghai, China.
Peterson, Alex., Central West Pub. Serv. Co., Omaha, Nebr.
Richardson, Jas. Ray, 223 Sheldon Ave., S.E., Grand Rapids, Mich.
Schatz, Nathan, 1845—52nd St., Brooklyn, N.Y.
Shen, C. Mayo, 18 an Check L8, Scott Rd., Shanghai, China.
Thomas, Alfred J., c/o L. J. Healing & Co., Ltd., Yusen Bldg., Tokyo, Japan.
Uline, Wm. A., Northern Elec. Co., Guy & Notre Dame Sts., Montreal, Que., Can.

Engineering Literature

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

ARCHIV FÜR TECHNISCHES MESSEN. Lieferungen 13–14, July-Aug., 1932. Munich and Berlin, R. Oldenbourg. Illus., 12x9 in., paper, 1.50 rm. each. Section of a comprehensive work which is being published serially on methods of technical measurement and measuring instruments. Each number contains brief articles by specialists; also usually bibliographies. Punched for loose-leaf binder and classified for convenient reference.

CHEMICAL ENCYCLOPAEDIA. By C. T. Kingzett. 5 ed. New York, D. Van Nostrand, 1932. 1014 p., 9x6 in., cloth, $10.00. A convenient one-volume reference work in nontechnical language intended primarily for merchants, manufacturers, and all interested in chemical processes; also useful to professional chemists for rapid reference. A brief, clear account of almost every chemical substance of practical importance.

CHROMIUM PLATING. By E. S. Richards. Phila., J. B. Lippincott, 1932. 131 p., illus., 8x5 in., cloth, $3.50. Intended for those responsible for plating plants and devoted to the practical production of the plate and methods for ensuring regular outputs of good work. Shop equipment and methods of preparing, plating, and finishing work described in detail.

DIESELMOTOREN IN DER ELEKTRIZITÄTSWIRTSCHAFT INSBESONDERE FÜR SPITZENDECKUNG. By M. Gercke. Berlin, Julius Springer, 1932. 92 p., illus., 10x6 in., paper, 6 rm. A study of the suitability of Diesel engines for electric power plants and of the extent to which they have been used. The author gives data upon plants throughout the world, discusses advantages of the Diesel as standby and peak load equipment, and compares its economy with that of steam equipment.

EINFÜHRUNG IN DIE METALLOGRAPHIE. By P. Goerens. 6 ed. Halle (Saale), Wilhelm Knapp, 1932. 392 p., illus., 10x7 in., paper, 15.50 rm., bound, 17 rm. Since the fifth edition of this book much has been done to clarify the theory of metallography and to extend its practical use. These advances have been used in the revision. A new chapter on the X-ray examination of metals is incorporated. Practical application of metallography in iron testing has been enlarged upon and the advantages of metallographic investigation in studying flaws emphasized.

EINFÜHRUNG IN DIE THEORETISCHE KINEMATIK. By R. Müller. Berlin, J. Springer, 1932. 124 p., 9x6 in., paper, 6.80 rm. This textbook presents the course given by the author at the Darmstadt Tech. Col. It is intended primarily for students of mechanical and electrical engineering, but is adapted also to students of mathematics. Presents theoretical principles underlying machine design, in general purely geometrical.

ELEKTROTECHNICKÁ ROČENKA ESČ 1932. By B. Pařez. Prague, Elektrotechnický Svaz Československý, 1932. 320 p., illus., 12x9 in., cloth, Kc 200. The yearbook of the Czechoslovak Electrical Society giving a complete description of the condition of the electrical industry in the country, and containing regulations governing electric utilities; very complete statistics upon light and power, radio, telephones, etc.; lists of manufacturers and other data of value to engineers.

ELEMENTS OF PHYSICS. By A. W. Smith. 3 ed. New York & London, McGraw-Hill, 1932. 778 p., illus., 9x6 in., cloth, $3.50. A college textbook giving a survey of the field of physics with considerable emphasis upon modern physics. An endeavor to encourage the student to form physical images of the principles presented and to apply them to the explanation of every-day experiences. Applications of physics to agriculture, engineering, and every-day life are used largely to illustrate the principles.

ENCYCLOPAEDIA OF OXYACETYLENE WELDING. 2 v.; V. 1. Pipe Construction. 83 p. V. 2. Construction of Apparatus and Containers. 80 p. Geneva, Switzerland, International Advisory Committee for Carbide and Welding Technique. (Gift of Acetylene and Welding Consulting Bureau, Ltd., London). 1932. Illus., 12x9 in., cloth, 10s.6d. The first 2 vol. of a series of 6 forming an album on the applications of oxyacetylene welding. Each volume contains about 80 plates of welded structures, and brief explanations in 5 languages. The engineer or manufacturer will find the work interesting and suggestive of many uses for the process.

FEDERAL RADIO COMMISSION, Its History, Activities, and Organization. (Inst. for Government Research, Service Monographs of the U.S. Govt. No. 65.) By L. F. Schmeckebier. Washington, Brookings Institution, 1932. 162 p., 9x6 in., cloth, $1.50. A monograph giving an accurate account of the history and development of the Commission, describing its specific activities in detail and explaining its organization. The regulations governing its work, its appropriations, and expenditures, are presented; with a full bibliography.

HEAT-TREATMENT AND ANNEALING OF ALUMINIUM AND ITS ALLOYS. By N. F. Budgen and D. Hanson. London, Chapman & Hall, Ltd., 1932. 341 p., illus., 10x6 in., cloth, 25s. The theories of hardening and strengthening aluminum alloys, practical methods, and equipment for thermal treatment, its effects upon the physical properties of wrought and cast material, and the annealing of wrought and cast aluminum and its alloys, are discussed comprehensively for the first time. Scattered information is collected and presented for practical use. Dr. Budgen is superintendent of a large English aluminum foundry.

INDEX TO THE LITERATURE OF FOOD INVESTIGATION. V. 4, No. 1, March 1932. London, Gt. Britain, Dept. of Scientific and Industrial Research. 135 p., 10x6 in., paper, 2s. 6d. (Obtainable from the British Library of Information, 270 Madison Ave., New York, $.70.) This index, printed every 6 months, is useful to all those concerned with food production and preservation. Nearly 100 periodicals are covered, entries are classified conveniently, and annotations provided. The engineering section will be found useful as a bibliography of investigations of refrigeration and air conditioning.

INTERIOR AND EXTERIOR LIGHTING. By C. E. Weitz. Scranton, Pa., International Textbook Co., 1931. Pt. 1, Interior Lighting, 41 p.; Pt. 2, Exterior Lighting, 77 p., illus., 8x5 in., cloth, $1.75. A description of modern lighting practise, advising choice of methods and fixtures, standards of illumination for various purposes, and similar matters. A help to those wishing elementary advice in concise form.

INTRODUCTION TO PHYSICAL SCIENCE. By C. W. Miller. New York, John Wiley & Sons, 1932. 403 p., illus., 9x6 in., cloth, $3.00. To provide a preliminary text that will offer the necessary fundamental training and at the same time give a broader outlook on modern physics. An effort to lead the student by natural steps from the beginnings of scientific thought to the results of modern research. The text is elementary and advanced mathematics beyond the high school stage are omitted.

LICHTBOGEN - STROMRICHTER FÜR SEHR HOHE SPANNUNGEN UND LEISTUNGEN. By H. Marx. Berlin, J. Springer, 1932. 167 p., illus., 9x6 in., cloth, 18.50 rm. A book to show that it is possible to transform and rectify high voltage currents by means of arcs burning in currents of compressed air. The principles underlying this rectifier and practical methods for constructing arc rectifiers are presented, based largely upon the investigations of Prof. Marx and his colleagues at the Braunschweig Technical High School.

MACRAE'S BLUE BOOK, consolidated with Hendricks' Commercial Register. 40th Annual Edition. Chicago and New York, MacRae's Blue Book Co., 1932–1933. 3333 p., illus., 11x9 in., cloth, $15.00. A buying guide for manufacturers, railroads, mines, municipalities, public utilities, contractors, engineers, and mills. Materials are fully classified and well indexed, with a directory of manufacturers and local distributors, a section describing the trade facilities in towns of more than 1,000 inhabitants, and a directory of trade names. A section is devoted to Canada.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN DES GHH-KONZERNS, Band 2, Heft 2, July 1932. Berlin, VDI-Verlag, 35–56 p., illus., 12x9 in., paper, 2.50 rm. This number gives a description of a new spectrum photometer and its use for the rapid analysis of alloys, especially iron; an article on the resistance of welded bars, a comparison of the calculated resistance of ships with the results of tests on models, and an essay on entropy and probability.

MODERN MATERIALS HANDLING. By S. J. Koshkin. New York, John Wiley & Sons, 1932. 488 p., illus., 9x6 in., cloth, $6.00. A large amount of condensed information in convenient form upon modern methods and equipment for handling materials in factories. Cranes, overhead transporters, trucks, conveyors, hoists, coal, and ash handlers, etc., are considered. Methods of handling different materials and the choice of equipment for any given purpose are discussed.

MODERN PHYSICS. By G. E. M. Jauncey. New York, D. Van Nostrand, 1932. 508 p., illus., 9x6 in., cloth, $4.00. Intended for the student with one year of college physics and mathematics, and directing attention to X-rays, the quantum theory, cosmic rays, relativity, radioactivity, astrophysics, and similar topics. The book is designed to give the student some knowledge of the parts of physics which are now in process of active formation or only recently developed.

NOMOGRAM, the Theory and Practical Construction of Computation Charts. By H. J. Allcock and J. R. Jones. London & New York, Isaac Pitman & Sons, 1932. 209 p., 9x6 in., cloth, $3.00. The authors discuss the general theory of nomograms and give practical directions for making and using all classes of computation charts of scientific or industrial usefulness. The book covers the field satisfactorily and will be welcomed by calculators.

PHOTOCELLS AND THEIR APPLICATION. By V. K. Zworykin and E. D. Wilson. 2 ed. New York, John Wiley & Sons, 1932. 331 p., illus., 8x5 in., cloth, $3. The theory of the photoelectric cell, its manufacture, and its use in picture transmission, television, sound production, and for other industrial purposes, are set forth concisely, yet comprehensively. A book useful to the untrained reader as well as to the specialist. The new edition has been revised thoroughly and 5 new chapters added.

RADIO ENGINEERING. By F. E. Terman. New York & London, McGraw-Hill, 1932. 685 p., illus., 9x6 in., cloth, $5. This textbook aims to present a comprehensive engineering treatment of the more important vacuum tube and radio phenomena for the senior year of an electrical engineering curriculum. The first part of the book is devoted to the theory of tuned circuits, the fundamental properties and the applications of vacuum tubes of importance to all electrical engineers. The second part discusses more specialized radio topics such as radio receivers and transmitters, wave propagation, antennas and direction finding.

SYMPOSIUM on RUBBER: Cleveland, Ohio, March 9, 1932. Philadelphia, Am. Soc. for Test. Mats., 1932. 160 p., illus., 9x6 in., paper, $1.75.—The papers deal with the manufacture of rubber products and the properties of rubber as an engineering material. Topics discussed include properties of crude and reclaimed rubber, vulcanization, compounding, reinforcing, flexing of rubber products, shock and vibration properties of rubber, deterioration under friction, resistance to water, chemicals and electrical characteristics, and uses as an adhesive.

Die TECHNISCHE ELEKTROLYSE WÄSSERIGER LÖSUNGEN. (Handbuch der technischen Elektrochemie v. 1, 2 pts.) By V. Engelhardt. Leipzig, Akademische Verlagsgesellschaft 1931–32. Pt. 1, 613 p., 52 rm., cloth; Pt. 2, 331 p., 32 rm., cloth, 10x7 in.—With the assistance of German and American specialists, Dr. Engelhardt has undertaken the preparation of a comprehensive, systematic treatise upon the technical uses of electrochemistry and electrometallurgy. This, the first of 5 volumes, is devoted to the electrolysis of aqueous solutions. General discussion of theoretical principles and a general review of apparatus (baths, electrodes, diaphragms, etc.) open the volume; then attention is turned to the electrometallurgy of aqueous solutions. The electrolysis of industrial metals is then discussed by various experts. Throughout, attention is concentrated upon present practise, and much note given to descriptions of modern plants, plant and operating costs, and statistics of production and prices. Bibliographies included. Useful to all in search of practical information.

Engineering Societies Library

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MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Industrial Notes

M. P. Ellis Resigns From Steel & Tubes, Inc.—Announcement has been made by Morgan P. Ellis, of his resignation as general sales manager of Steel & Tubes, Inc., Cleveland, O. Mr. Ellis has not revealed his plans for the future.

Engineering Firm Opens Cincinnati Office.—The Burns & McDonnell Engineering Co., consulting engineers, has opened an office at 612 Dixie Terminal Bldg., Cincinnati, in charge of C. F. Lambert, a member of the firm. This company has been established at Kansas City for thirty-five years, and has had an office in Los Angeles for the past ten years. The firm specializes in municipal engineering, including electric light plants, water works, sewer systems, investigations, appraisals, and reports.

Ball Bearing Sales Consolidation.—The Marlin-Rockwell Corporation has consolidated the sales activities formerly carried on independently by its subsidiary companies—Gurney Ball Bearing Division, Standard Steel & Bearings, Inc., and Strom Bearings Co. The bearings manufactured by these companies will hereafter be marketed through the corporation's sales organizations, with offices at Jamestown, N. Y., Plainville, Conn., and Chicago. Branch sales offices will be maintained at the former addresses in Detroit, Cincinnati, Cleveland, Los Angeles, and San Francisco. A new branch sales office has been opened at 40 W. 63rd St., New York.

New York Offices for Amerika-Interessen, Inc.—Offices have been opened in the Chrysler Building, New York, by Amerika-Interessen, Inc., organized as the American unit of A. G. Fuer Amerika-Interessen, operating also in Berlin, Paris, and London. According to Botho Lilienthal, president, in order to surmount tariff barriers, the corporation plans to make available to the manufacturers of one country such devices, processes and patents that have been proved successful in other countries. For manufacturers who wish to augment their incomes by obtaining business abroad, but cannot do so by exports, agreements are negotiated covering production and marketing rights. This is done by issuing licenses on a royalty basis or by the outright sale of the manufacturing and marketing rights for the country involved. The American company's engineers have selected from over 1,000 offerings, about 100 devices that seem suitable for immediate exploitation in this country. These are in many fields and include such widely different lines as machine tools and appliances, electrical devices, temperature indicators and recorders, optical instruments, advertising displays, air conditioning equipment, welding processes, steel house construction, etc.

Splash-Proof Motor.—The Louis Allis Co., Milwaukee, has introduced a splash-proof motor safeguarded to prevent entrance of water splashed with terrific pressure from any angle, yet adequately ventilated and built in the same dimensions as a standard open motor. A double baffle in an elliptical-shaped air passage in each end-bell provides the unusual protection offered by this new motor. The unique construction permits free passage of ventilating air yet traps and drains water splashed into the air openings at the bottom of the elliptical-shaped chambers. Another original feature is a shaft guard which breaks the force of a stream directed along the shaft extension and prevents water from entering the bearing chamber.

New Circuit Breaker.—The Delta-Star Electric Co., Chicago, announces a new 5 kv, 3,000 amp, 50,000 kva three-pole, non-oil throwing type, indoor oil circuit breaker. The welded square tank with full rounded corners, is fabricated of heavy steel plate, thoroughly reinforced and banded. The interior is completely lined with arc-resisting material. The straight line motion mechanism, composed of non-magnetic steel parts, operates under a heavy, Everdur domed tank head, eliminating magnetic heating. The terminals and bushings are made of copper bars with wrapped, impregnated, bakelized paper. These terminals are held to the domed head by means of non-ferrous clamps. The breaker lift rods travel through roller guides, insuring positive alignment with low friction losses, and high speed of contact operation.

Another Burndy Lug.—Continuing on a program of developing connectors for wires and cables based on the clamp type principle, the Burndy Engineering Co., Inc., New York, has developed a clamp type lug that possesses new features which minimize installation costs. To install the new type of Burndy lug requires only a wrench and a minute or two of time. The compression principle used provides contact over a large cable area in close intimacy with the contact tongue of the lug. Designs of the new device for all standard wire and cable sizes, as well as odd combinations of angle connections for single and multiple conductors have been prepared. Since its introduction there have been a number of notable installations, including the use of thousands of the lugs in the Rockefeller Center group of buildings in New York.

New Electrostatic Voltmeters.—A complete line of electrostatic voltmeters, designed to provide a ready means for measurement of high d-c and a-c voltages, particularly in circuits of high resistance where any appreciable current taken by a voltmeter introduces considerable error, has been developed by Ferranti, Inc. The instrument is entirely free from wave form, frequency and temperature errors, and is available in the single range projecting, flush or portable types, fitted in $2^1/_2$" moulded bakelite cases. The meter can be supplied in nine different ranges having full scales from 450 volts to 3,500 volts, the capacity ranging from 30 micro-microfarads with full scale deflection for the 450-volt meter, to 5 micro-microfarads for the 3,500-volt instrument. The meter is designed with an 80° scale readable to the unusually low figure of 20% of the full scale value.

A safety resistance of high value is fitted inside the case of each instrument to limit the current in the event of a flash-over due to over-voltage. This resistance renders the meter free from damage to over-load provided that the over-load is maintained for only a short time. The Ferranti electrostatic voltmeter is essentially a variable condenser, and although there is a minute current passed by the instrument on alternating current circuits, there is no power loss as the current is 90° leading with respect to the voltage and has no "in-phase" component. The instruments are magnetically damped, and have reasonably high torque for this class of meter.

Trade Literature

Uses of Hard Rubber in Industry.—Catalog 1, 18 pp. Describes hard rubber products for industrial purposes. Illustrations include applications in electrical manufacturing. American Hard Rubber Co., 11 Mercer St., New York.

Midget Motors.—Bulletin, 4 pp. Describes "Barcol Midget" shaded pole induction motors. Other bulletins on two-pole and four-pole undirectional motors and two-pole geared-head, and reversing motors, 1–100 hp and less, are also available. Barber-Colman Co., Rockford, Ill.

Constant-Tension Drive.—Bulletin 602, 4 pp. Describes the Reliance automatic tension regulator for application to any process requiring a constant tension in material being wound or unwound from a reel. Reliance Electric & Engg. Co., 1088 Ivanhoe Rd., Cleveland, O.

New Metering System.—Bulletin 1960, 8 pp. Describes a new metering system combining the advantages of the new OC detachable watthour meter, the new portable stroboscopic standard, and the nofuse load center. Each of these pieces of equipment is illustrated and its use in the system explained. The field testing method provided by the stroboscopic standard constitutes a new element in metering. Westinghouse Elec. & Mfg. Co., Newark, N. J.

Ratchet Type Relay.—Bulletin CX 464. Describes the "Dunco" ratchet type, or sequence relay. The energizing of the coil moves the pawl, engaging a ratchet which actuates a cam or cams to open or close the contacts. By a minor adjustment of the cams moving the contacts together, these relays can be made single pole, double break; double pole, single break; or single pole, single break, double throw. Relays can be furnished for various voltages, alternating or direct current. Struthers Dunn, Inc., 139 No. Juniper St., Philadelphia, Pa.